JOURNAL

OF

THE FRANKLIN INSTITUTE,

OF THE

State of Pennsylvania,

AND

AMERICAN REPERTORY.

FEBRUARY, 1847.

CIVIL ENGINEERING.

Twentieth Annual Report of the President and Directors to the Stockholders of the Baltimore and Ohio Railroad Company.

(Continued from page 8.)

Hon. LOUIS MCLANE,

President Baltimore and Ohio Railroad Company:

Dear Sir,—In compliance with your request, I have the honor to submit a general statement of the operations of the Baltimore and Ohio railroad during the past year.

By reference to the reports of the Superintendents of transportation and machinery, it will be seen that there have been transported to and from the several points on the main stem, 193,916 tons of merchandize, and 280,264½ passengers, showing the very remarkable increase in the former of 52,509 tons, and in the latter, of 77,806 passengers over the year previous. This increase in the tonnage, it will be observed, has occurred, upon the most part, in the transportation of miscellaneous trade, and is the more gratifying, because it gives evidence of the importance attached to this route as an avenue of communication with the west, even in its present unfinished condition; and connecting, as it does, with a most imperfect mode of transportation between Cumberland and the Ohio river.

The increase above alluded to, occurred chiefly between the months of September and May last. The great drought of the summer of

1845, having rendered the Pennsylvania canals very inefficient during the last autumn, and the violent effects of the breaking up of the last winter causing them to be almost entirely useless until a late period of the spring.

This large amount of trade thrown thus suddenly upon the road, although extremely gratifying in many respects, produced considerable embarrassment on account of the inadequacy of the motive power and cars for its accommodation. To such an extent, indeed, at one period, did this embarrassment exist, that for a short time it was found absolutely indispensable to refuse to receive merchandize for transportation, the depot being crowded to its full capacity, and the forwarding houses at Cumberland being unable to procure wagons in sufficient numbers for its prompt despatch.

It will be readily perceived, that in the effort to accommodate such a trade, both the locomotives and cars were pushed to their utmost capacity, and indeed beyond what would, under other circumstances, have been considered consistent with a proper economy in regard to repairs. It not unfrequently happened that the engines, after performing their duty during the day, had necessarily to be repaired after night, in order that they might be ready for use the next morning—a system altogether too expensive, and too imperfect to be allowed, except under such circumstances as then existed. But, under this state of affairs, it became the duty of the board, to endeavor to procure, at as early a day as possible, an increase of power and cars; and they accordingly directed the committee of transportation and machinery, by resolutions of the 3d December, 1845, March 11, 1846, April 8, 1846, and June 10, 1846, to procure six locomotives of the largest class, and three of the second class; and also to cause to be constructed, in the Company's shops, one locomotive of the largest class, and one of the second class; 30 iron coal cars, 20 house cars, 42 gondola cars, and 20 stock cars.

The board, under a report and resolution of the committee of transportation and machinery, on the 8th July last, have further authorized, in view of the probable increase of the trade during the year 1847, contracts to be made for five first class engines, and 30 merchandize cars. This last authority, has not, up to the present moment, been acted upon, except in regard to the merchandize cars, which are now in course of construction. Whether the increase in the coal trade will be such as will render the five locomotives, above referred to, necessary, remains to be ascertained, and may depend upon the course the Company may take in regard to that subject. Only three of the engines, above referred to, have been delivered. One of the engines ordered to be built in the Company's shops, is in a state of forwardness, and those contracted for, will be delivered in the course of this year. Nearly all the cars ordered have been completed, and are in use upon the road. This large increase of machinery and cars, rendered further accommodation for their protection at the Mount Clare and Cumberland depots indispensable; and, under the recommendation of the engineer of machinery and repairs, the board authorized the extension and erection of the buildings and other improvements

at those points, under resolutions of the 11th March, and 13th May last. These circumstances, it is believed, will sufficiently explain the increase, during the year, of expenditure in the repairs of locomotives, the cost of new machinery, and of expenditures upon depots and water stations.

The quantity of coal brought to market over the road during the year, amounts to 18,393 tons, being 2373 tons more than that of last year. It must be observed, however, that of this quantity, 12,682 tons have been transported since May last, that being about the period when several of the coal companies in Allegheny county commenced their operations. The contract with the New York and Maryland Iron and Coal Company, to which reference has been had in former reports, having been abrogated, and that Company having devoted its capital and energies to the manufacture of iron, the quantity of coal received from them during the year has been very inconsiderable.

The augmentation of the trade, and the occurrence of accidents almost daily, which involved serious derangement of the machinery, and in some instances the loss of life to persons engaged upon the trains, necessarily had the effect of calling the attention of the board to the condition of the road, and accordingly, on the 8th of October, 1845, a resolution was adopted directing the chief engineer to take into consideration and to report to the board, a system for the gradual extension and improvement of the road from Harper's Ferry towards Baltimore.

Upon this resolution the chief engineer made an elaborate report, in which it was satisfactorily shown that the condition of the road was such as to require its re-construction. The comparative merits of the plate rail and the edge rail, in point of repairs and renewals of track, repairs and renewals of machinery, and expenses upon the motive power, are very fully discussed, and the advantages are shown to be most decidedly in favor of the edge rail.

The following table, extracted from the chief engineer's report, will exhibit, at one view, the cost of construction, and the relative expense of maintaining the two descriptions of track under different amounts of trade:

TABLE OF THE COST

Of Constructing and Maintaining the two kinds of Track under the various amounts of Trade.

Description of Track.	Estimated cost of Construction per mile.	Interest at six per cent. on cost, per mile.	Interest at six per cent. on cost of 92 miles.	Average of 7 years, ending October 1st, 1845. Trade of 47,008 tons. Repairs and Renewals per mile.	Repairs and Renewals for 92 miles.	Interest, Repairs, and Renewals for 92 miles.	Capital equivalent to the latter, at 6 per cent.	Year ending October 1st, 1846. Trade of 116,522 tons. Repairs and Renewals per mile.	Repairs and Renewals for 92 miles.	Interest, Repairs, and Renewals for 92 miles.	Capital equivalent to the latter at 6 per cent.	Year ending Oct. 1st, 1847. Trade of 151,522 tons. Repairs and Renewals per mile.	Repairs and Renewals for 92 miles.	Interest, Repairs, and Renewals for 92 miles.	Capital equivalent thereto at 6 per cent.
Plate Rail,	$3,500	$210	$19,320	$653	$60,076	$79,396	$1,323,266	$1,019	$93,748	$113,068	$1,884,466	$1,201	$110,492	$129,812	$2,163,533
Edge Rail,	10,560	644	58,328	288	26,496	84,824	1,413,400	396	36,432	94,760	1,579,333	449	41,308	99,636	1,660,600
Difference. In favor of Plate Rail,	7,060	424	39,008			5,428	90,134								
Against Plate Rail.				365	33,580			623	57,316	18,308	305,133	652	69,184	30,176	502,933

From the preceding tabular statement it will appear that if, instead of 92 miles of plate rail, we had an equal number of miles of edge rail, the saving under the probable trade of the present year of 116,522 tons, would have amounted to $18,308, and under the 151,522 tons of the coming year to $30,173, in the maintenance of way alone. From these sums there should, however, be deducted the annual interest upon that part of the capital invested in the present plate rail track, which would be sunk by the substitution of the new track. Of the $3500 per mile, the estimated cost of the former, about $1500 would be realized by the sale or use of its materials, leaving $2000 per mile, on which the interest at six per cent. is $120 per annum per mile, and for 92 miles $11,040, which, taken from $18,308, and from $30,176, leaves $7268, as the saving for 1846, and $19,136 for that of 1847.

These results are founded upon estimates of the average wear and tear of the two tracks for a series of years under the respective amounts of trade assumed. But, in fact, while the plate rail track, if continued, would certainly cost the sums set down to it during this year and the next, the edge rail track, if now laid down and ready for use, would, for those two years, cost very much less than the amounts assigned to it. Indeed, considering the perfectly consolidated character of the road bed upon which it would be placed, it is believed that for the first year it could be maintained in repair for $125 per mile, and for the second year for $195 per mile.

In confirmation of this supposition, and in support of the above estimate of the repairs and renewals of an edge rail track like that west of Harper's Ferry, under the several amounts of trade assumed, may be adduced the fact that the H rail track, of which there are 19 miles east of Harper's Ferry, has cost an average of about $210 per annum per mile to maintain it since it was laid down, seven years ago, and the ∩ rail track west of Harper's Ferry has cost, for the three years of its duration, about $190 per mile. The maintenance of the H rail track of the Washington branch has, in nine years experience, cost about $275 per mile per annum. The saving of the edge, compared with the plate rail, would then, for the first year, be $32,200, instead of $7268, and for the second year, $44,344. instead of $19,136, as just stated.

From the preceding comparison, founded, it is firmly believed, upon the safest and most satisfactory data, furnished by the ample experience of our own road, and substantiated by that of other works, we are authorized to draw the conclusion that, if at this date, we had a new edge rail track instead of the old plate rail track east of Harper's Ferry, we should have saved not less than $32,000, during the past year, in the cost of its maintenance, under the estimated trade of this year.

Again, the following table extracted from the same report, will shew the probable reductions in the cost of working the road between Baltimore and Harper's Ferry, due to the substitution of an edge rail for the present plate rail between those points:

Tabular Exhibit of the Probable Reductions in the Cost of Working the Road between Baltimore and Harper's Ferry, due to the Substitution of an Edge Rail for the present Plate Rail Track between those points.

DESCRIPTION OF TRACK.	Seven years preceding Oct. 1, 1845. Trade of 63,632 tons.					Year ending October 1, 1846. Trade of 157,731 tons.					Year ending October 1, 1847. Trade of 205,109 tons.				
	Repairs and Renewals of Track, including interest	Repairs and Renewals of Machinery.	Motive power Expenses.	Interest on Capital invested in Burthen Cars.	TOTALS.	Repairs and Renewals of Track, including interest	Repairs and Renewals of Machinery.	Motive Power Expenses.	Interest on Capital invested in Burthen Cars.	TOTALS.	Repairs and Renewals of Track, including interest	Repairs and Renewals of Machinery.	Motive Power Expenses.	Interest on Capital invested in Burthen Cars.	TOTALS.
Plate Rail,	$79,396	$49,099	$54,239	$1,620	$184,354	$113,068	$85,922	$68,372	$7,680	$375,042	$129,812	$103,596	$85,371	$10,800	$339,579
Edge Rail,	84.824	42,030	40,680	1,350	168,884	94,760	73,553	51,274	6,384	225,971	99,636	88,682	64,028	9,000	261,346
Differences, all against Plate rail but the 1st, marked (a.)	a 5,428	7,069	13,559	270	15,470	8,308	12,369	17,098	1,296	49,071	30.176	14,914	21,343	800	68,233

From the summary of the savings under the four heads of expenditure, above considered, it is seen that, with an edge rail, the Company would have saved in the operation of the last seven years, the sum of $15,470; and that with such a rail, they would have saved in the working of the road during the past year, $49,071; and, in that of the year following, $68,233, *after allowing six per cent interest on the cost of the new track.* And if interest at the rate of $120 per mile be allowed upon the sunken capital of the old track, if it were now abandoned, the saving would then have been for the present year, $38,031; and for the next, $57,193, *clear of all drawbacks whatever.*

And if we look no further in estimating the repairs of the new track than two years ahead, the saving would be $62,963 for the first, and $82,401 for the second year.

This, then, is the result of the balance of "advantages and disadvantages," so far as they are susceptible of being estimated in money, upon principles and data which are demonstrably true. Under these circumstances the board, being deeply impressed with the necessity that the road should be repaired in the most substantial manner, on the 5th of January last, in conformity with the report of the Committee of Finance, passed the following resolution:

"*Resolved*, That it is expedient that all contracts necessary to the immediate re-construction of thirty miles of the road be made without delay."

In conformity with this resolution contracts were entered into with the New York and Maryland Mining Company, and the Covington Manufacturing Company, for a supply of iron, and the whole line of the road to the extent of thirty miles was put immediately under reconstruction.

About one-fourth of this distance has been completed, and it is confidently expected that the remainder will be ready for use before the 1st of January next.

In entering upon a work requiring so large an expenditure, the Board of Directors calculated upon raising the necessary means by a sale of the Company's bonds to the extent of one million of dollars—and they accordingly authorized bonds to be issued to that extent. Efforts were made both in this country and Europe to that effect, but so far without much success. It is hoped, however, that the measures which have recently been adopted by the board will have the effect of placing the bonds upon very high ground as an investment, and of insuring for them a ready sale in the course of the coming year.

The number of passengers carried over the Washington road during the year was 157,156, showing an increase over the year previous of 53,568, and the statement of the revenue shows an increase of $21,851·50 for the same period.

It is true that a large portion of this increase is due to the great number of passengers which passed over the road during the continuance of the national fair held at Washington city in the month of May last—but a comparison of the receipts from the road independently of this consideration, since the period of the reduction of fare in the month of September, 1845, will show a manifest and decided increase over

the corresponding period when the high rates were charged, and the competition with the stages existed.

The condition of the tracks upon this road is entirely satisfactory—the cost for repairs is comparatively light, and the trains proceed without embarrassment, and with but little interruption.

During the last winter the citizens both of Virginia and Pennsylvania, feeling a deep interest in the extension of the road to the Ohio river through these States, made earnest appeals to their respective legislatures for the right of way.

In Virginia the effort resulted in nothing more than some slight modifications of the law passed at the previous session, but retaining the most objectionable features in full force.

In Pennsylvania a law was passed authorizing the Company to pass through that State, which is exceedingly embarrassing in many of its provisions, and moreover is made to be dependent for its vitality upon the failure on the part of the citizens of Philadelphia to subscribe the sum of 3,000,000 of dollars to a Company incorporated at the same session to construct a road from that city to Pittsburg. To what extent that subscription has been made I am not informed, but even if it should fail to the extent required, it is not believed that the law could be accepted by this Company.

Authority, however, was conferred upon the Pittsburg and Connellsville Railroad Company to extend their work to the Pennsylvania line upon any of the waters of the Youghiogeny river, and it is understood that that Company is about to prosecute its work with a good degree of energy. Should it succeed in accomplishing its object to the point designated, the distance between its terminus and that of the Baltimore and Ohio Railroad at Cumberland, will be so short, as to render the connexion between the two works entirely practicable.

When this is accomplished, a continuous line of railroad between Baltimore and Pittsburg will be established, throwing open the fertile districts of Pennsylvania through which it will pass, and bringing the counties bordering even upon the great lakes to pour their tribute of commerce and wealth into the lap of *our own city*.

I remain, very respectfully,

Your obedient servant,

SAMUEL JONES, JR.

Baltimore, Oct. 7th, 1846.

Comparative Summary of the operations of the "MAIN STEM" *of the* BALTIMORE AND OHIO RAILROAD,—

from 1836 *to* 1846, *inclusive.*

Official Years.	FROM PASSENGERS.		FROM TONNAGE.														AGGREGATE of Passengers and Tonnage.
			WESTWARDLY.				EASTWARDLY.						TOTAL.				Amount from Tonnage.	
	Passeng'rs	Amount.	Tons.	h.	qr.	lb.	Bls. Flour.	T's Coal.	Tons.	h.	qr	lb	Tons.	h.	qr.	lb.		
1836	157,102	$128,126·30	25,898	5	1	0	172,664		40,805	3	3	1	66,703	9	0	1	$153,186·23	$281,312·53
1837	140,699	145,625·29	33,901	5	3	10	113,870		40,696	4	3	5	74,597	10	2	15	155,676·09	301,301·38
1838	150,516½	166,693·53	30,079	11	1	3	142,512		47,447	7	3	24	77,526	19	1	2	198,530·79	365,224·32
1839	152,501	173,860·44	45,878	4	3	10	264,033		54,573	7	1	4	100,451	12	0	14	233,487·06	407,347·50
1840	152,418	177,035·75	25,638	10	0	9	392,449		62,736	3	1	24	88,374	13	2	8	255,847·95	432,883·70
1841	171,629½	179,615·80	23,442	13	0	19	255,818		42,056	4	3	0	65,498	17	3	19	211,454·07	391,069·87
1842	154,568	181,177·35	30,243	15	3	9	233,539		37,600	14	0	19	67,844	10	0	3	245,315·31	426,492·66
1843	149,533	274,617·27	27,191	16	3	3	266,146	4,964	55,523	11	2	20	82,715	8	1	23	300,617·81	575,235·08
1844	173,821	336,876·32	33,224	16	1	2	241,550	5,433	69,886	11	1	23	103,111	7	3	0	321,743·66	658,619·98
1845	202,458½	369,882·30	50,541	16	2	23	235,602	16,020	90,865	3	3	20	141,407	0	2	18	368,720·88	738,603·18
1846	280,264½	413,341·59	83,559	2	3	9	412,776	18,393	110,356	18	0	22	193,916	1	0	6	468,345·94	881,687·53
Totals,	1,885,511	$2,546,851·94	409,599	18	3	22	2,730,959	44,810	652,547	11	2	12	1,062,147	10	2	9	$2,912,925·79	$5,459,777·73

(A)

Dr. *The Baltimore and Ohio Railroad Company.* Cr.

Stock in the Washington Branch Road, .		$1,032,600·00	Loan at six per cent., . .	$1,000,000·00
Cost of road to Harper's Ferry, including real estate and depots, locomotives, passenger and burden cars, &c., &c., . .		4,000,000·00	Loan No. 2, at six per cent., . Stock, . . .	6,984 00 7,000,000·00
Cost of road west of Harper's Ferry,		3,623,606·28	Baring, Brothers & Co., London, for Balance now due,	103,708·95
Coal trade, for amount due on that account,		101,494·78	State of Maryland five per cent. sterling bonds,	3,200,000·00
Sterling bonds in the hands of Messrs. Baring, Brothers & Co., of London, .		3,181,005·11	Forfeited stock, for balance of that account,	183·45
City of Baltimore six per cent. stock on hand,		20,096·59	Interest received on city stock, . .	1,170·65
Sinking fund for the redemption of the million loan,		55,990·00	Revenue for balance of this account on the 1st Oct., 1845,	$581,767·21
Invalid fund for amount due by that account,		196·28	Amount which has accrued since,	895,315·22
New York and Maryland Iron and Coal Co., due by them, . . .		13,627·59	Dividend from Washington road in April last,	25,815·00
				1,502,897·43
Stock in the Pittsburg and Connellsville Railroad Company, for instalment paid, .		1,750·00	Less expenses, repairs, and interest, including the sum of $206,312·06 expended for re-construction, locomotives, improvement at depots, and various purposes on account of construction,	710,614·41
Cash in the hands of officers, .		15,094·63		792,283·02
Cash on hand, . .		58,868·71		
		$12,104,330·07		$12,104,330·07

(B.)

Statement of the Revenue and Expenses of the Baltimore and Ohio Railroad Company, on account of the Main Stem of the road for the year ending the 30th September, 1846.

The amount received for the transportation of Passengers, Mails, and Merchandize, for the year ending the 30th September, 1846, has been		$838,375·39
And the amount from the Coal Trade, inclusive of a debt of $13,627·69 due by the New York and Maryland Iron and Coal Company, is		56,939·83
Making an aggregate of		895,315·22
And the Expenses for the same period, have been the following, viz:—		
Expenses of Transportation, including Fuel, Salaries of the Superintendent, Agents, Conductors, &c.,	$146,057·91	
Repairs of the Road,	116,163·49	
Repairs of Locomotives,	56,051·17	
Repairs of Passenger Cars,	18,682·48	
Repairs of Burden Cars,	29,950·66	
Repairs of Bridges,	58,139·73	
Repairs of Depots,	10,742·71	
Repairs of Water Stations,	2,119·76	
Watching Bridges and Pumping water at Water Stations,	9,575·81	
Office and Incidental Expenses, including Salaries, House Rent, Fees to Counsel, &c., &c.,	7,356·16	
Making an aggregate of Expenses of		454,839·88
And shewing the net earnings of the road to be		$440,475·34

EXTRACT FROM TABLE C.

Receipts and Expenses.

Received for the Conveyance of Passengers, . .		$ 333,447·51
" " Transportation of Tonnage, .		446,266·00
" " " U. S. Mail, .		43,210·00
" " Use of Main Stem to Relay House by Passengers Washington Branch, . .		35,132·85
" " Use of Main Stem to Relay House, Tonnage,		18,289·18
" " Tolls upon Harper's Ferry Viaduct, .		1,551·23
" " Use of Cars on Winchester and Potomac Railroad,		3,790·76
		881,687·53
To which add amount of debt due by Maryland and New York Iron and Coal Company, . .		13,627·69
		895,315·22
And we have amount of Revenue as shown by Secretary's Statement B, ...		
Expended for Conveyance of Passengers and Mails,	$109,954·82	
" " Transportation of Tonnage,	319,145·46	
		429,100·28
Showing the net Revenue to have been		466,214·94
To which, in order to shew the same results as exhibited by Statement B, in the 20th Annual Report of the Baltimore and Ohio Railroad Company:		
Add cost of Repairs of Coal Cars, which item is included under the head of "*Coal Trade*," in the Secretary's statement,		2,530·93
And amount of decrease in value of Materials on hand for Repairs of Bridges and Passenger Cars, . .		714·54
		469,460·41
And deduct for permanent improvements to Bridges,	$23,381·56	
" " " " Locomotives and Tenders, .	4,365.03	
" " increased value of Materials on hand for Repairs of Railway and Burden Cars,	1,238·48	
		28,985·07
Surplus same as shown by statement B, above referred to		$ 440,475·34

Remarks.—Besides the tonnage transported as above, and for which the Company have received pay, there have been hauled of materials for repairs of railway and bridges, and of fuel for locomotives, &c., equivalent to 1,649,704 tons one mile; which amount, if added to the 14,614,986 tons hauled one mile by locomotives, as above stated, and their sum divided by the number of miles run by locomotives with tonnage trains, will show the average net load of each engine to have been 31½ tons, which is 2·3 tons greater than the average of the previous year.

There have been carried over the Winchester and Potomac Railroad, in the cars of this Company, equivalent to 596,947 tons one mile.

The average number of passengers in each train has been 69.

" " charge for the transportation of tonnage, 3·021 cents per mile.

" " charge for the conveyance of passengers, 3·116.

" " cost for repairs and renewals of locomotives, 7·753 cents per mile, run with trains.

The average charge for transportation, exclusive of coal, 3·419 cents per mile, run with trains.

The average cost of running the trains, exclusive of horse power in the streets of Baltimore, has been 59·8 cents per mile.

The average cost of running the trains, inclusive of horse power in the streets of Baltimore, has been 64·4 cents per mile.

The expenditures common to both passenger and burden traffic, have been divided in proportion to the number of miles run by locomotives, with the trains of each description; the greater speed of the passenger trains being considered as fully, if not more than, equivalent, to the somewhat greater average weight of the tonnage trains.

JAMES MURRAY,
Engineer of Machinery and Repairs.

(Tables D, E, F, omitted.)

The Gauge Commission.

Analysis of Evidence given before the Royal Commissioners appointed to investigate the subject of the diversity of Railway gauges.

Continued from Page 14.

Mr. Edward Bury: Is a manufacturer of locomotive engines, and has been such for 17 years. The heaviest engine made by witness has not exceeded 13 tons. 14-inch cylinder the largest yet made by witness; evaporating surface in proportion to the cylinder. Length of boiler increased from 8 feet 6 inches to 11 feet 6 inches. Space between fore and hind axle very considerably increased; interval 7 feet 6 inches. Witness considers the speed now attained on narrow gauge lines as great as is consistent with safety. The securities for the rails not sufficient to justify a higher rate of speed.

The transverse sleeper better than the longitudinal. There is a better chance of keeping the transverse right than the longitudinal sleeper; there is a great deal less packing with the transverse sleeper than the longitudinal sleeper; the under surface of the longitudinal sleeper is too great to admit of its being thoroughly and uniformly packed. Greater speed can be obtained on broad gauge than on narrow, because the speed depends upon the ratio of the stroke to the wheel, and on broad gauge a longer stroke and larger wheel can be had. The narrow gauge trains, however, can travel faster than is necessary or safe. If the Midland Counties were changed to broad gauge, the inconvenience to the London and Birmingham Company would be so great that they would be compelled also to change to broad gauge. Does not consider the rigidity of the rail essential to safety at high velocities; it would be better with a moderate elasticity in it. The best part of the Liverpool and Manchester Railway, and the most easily maintained, is that which occurs at Chat Moss, which is always elastic. The most difficult part to maintain on the Liverpool and Manchester line was that which went through Olive Mount, which is on a stone foundation. They have been obliged to take the

stone out for a considerable depth under the rails and fill it up with ballast. The engineer of the Bolton and Manchester line was anxious to make that line perfectly rigid. He built a continuous wall, and put upon it a T rail; but that did not stand at all; it knocked everything to pieces; it was always out of order, and they have been obliged to change it. The rail itself ought to be rigid, and the foundation on which it is placed should be elastic. Does not think any of the rails that have hitherto been laid are heavy enough. Has no knowledge of the feeling of proprietors in the mineral districts with respect to broad or narrow gauge, but considers that the narrow gauge is more suitable to their traffic, because the curves can be made sharper than on broad gauge, and bring them closer to the pit's mouth. Prefers a wider gauge than 4 feet 8½ inches, which witness believes too narrow for the engines and carriages and machinery working on the rails. 6 or 8 inches' additional width would be amply sufficient. Does not at present use outside cylinders, but some are now being made. Can get sufficient power on the narrow gauge, but a more convenient and accessible machine, with greater range and capability, could be constructed with a little additional width of rail. If witness had to determine on the gauge for a country having no railway, should certainly not adopt the 4 feet 8½ inch gauge. Would not adopt the 7 feet gauge. Should adopt an intermediate gauge, as preferable for engines, carriages, and wagons. Strength of passenger carriages on London and Birmingham Railway considerably increased, weighing 10 or 12 cwt. more than when the line was first opened; this increased strength essential to public safety as well as to the durability of the carriage. Reserve fund appropriated to purchase of new engines. Stock deteriorated within the last half year in consequence of being compelled to run the engines, &c., longer without the usual repairs, on account of the heavy traffic on the line.

Stock of Great Western Company valued at £534,000; of the London and Birmingham at £275,000, the latter doing the most work; difference accounted for by inferior size and expense of engines on London and Birmingham line. With the additional stock the expenses will come nearer the expenses of the Great Western Company. The 175 miles now worked with the original stock of the line. They have 93 engines and one borrowed from another Company.

Accidents from breaking of axles of rare occurrence; not one carriage axle broken within the last five years, and very few engine axles. The fracture of axle usually occurs in the journal; outside the wheel in the carriages, and inside the wheel in the engines. Engines frequently run some distance with a broken axle; have never had one so crippled as to be unable to get home; some have even taken out trains with a broken axle. The train taken off the line from broken axle in only one instance, when the front axle of the engine broke. Increased length of engine gives increased steadiness. Messrs. Sharp are manufacturing an engine with 18-inch cylinders; the cylinders are not placed outside the wheels, but inside, so that there is room for two 18-inch cylinders with the narrow gauge to be constructed inside the wheel, with the crank shaft. Impossible to say what load an

engine can be made to take on narrow gauge, but considers that for the ordinary traffic of the country, an engine on narrow gauge may be made of sufficient power to take at high speed both passenger and luggage trains. Present luggage engine on London and Birmingham line too small. Luggage trains often worked with several engines. The heaviest luggage train on this line was a train of 112 or 116 wagons, making upwards of 600 tons; for this train four engines were used.

Long trains much impeded by high winds. Has seen the transverse sleepers pushed out of their places, sometimes twisted like the letter S, by the expansion of the rail; this has occurred when sufficient allowance was not made between the rails for expansion. Average speed of express trains on London and Birmingham line 43½ miles an hour, including stoppages. They now use 13-inch cylinders; some of their engines for the express trains have been altered, by increasing the size of the boilers, an additional inch to the cylinders, and three inches to the wheel. Does not think it safe to run a small train very fast; should prefer more weight on the engine to make it run steadier; when any of the royal family are on the line, always put more carriages on than are required for passengers, in order to steady the train. Has frequently traveled by express train on London and Birmingham; there is very little oscillation; thinks the express train steadier than any other because it is better screwed up; everything is in higher order. Outside cylinders not yet tried on this line; they were tried on the Liverpool and Manchester and condemned; the oscillatory motion objected to; the boilers, however, were shorter than they are at present; there was a greater tendency to the yawing motion. Decidedly objects to the use of carriages with shifting wheels on account of the difficulty of keeping the securities always right. Experiments have been made in the United States to allow wheels to adjust themselves on curves; they were soon abandoned, it being impossible to keep them in order. A very small increase on the narrow gauge would afford great accommodation in the construction of the engine. The difficulty of oiling and cleaning the narrow gauge engines a very great inconvenience, and can only be felt by engine makers. They require more space for the tube of boiler, and a larger fire-box.

Mr. Benjamin Cubitt: Does not think an equal power can be obtained on narrow as on broad gauge. The narrow gauge does not allow width enough to get a fire-box large enough, and is cramped for width in getting strength for the working parts of the engine. Thinks it impossible to make so effective a boiler for narrow as can be made for broad gauge.

Has not particularly considered the relative advantages and disadvantages of outside or inside cylinders. There are about half-a-dozen outside cylinders upon the lines of which witness is superintendent. Total stock of engines about 120; all but 16 on 6 wheels. The Dover Company have ordered a large number of outside cylinders. Has ridden a good deal upon the outside cylinder engines. At first they travel as steadily as the inside cylinders, till they have been at work

eight or ten weeks, and then they begin to get side play and oscillate a good deal. This motion increases with the wear. The repairs upon outside cylinder engines are not more costly than upon inside cylinder engines.

The repairs required on the outside cylinder engines.

No. of Engine.	Maker.	Description.	Continued Working.	Miles Run.	Coke used. Total.	Coke used. p mile	Cost of Repairs. £.	s.	d.	Heating surface fire-box	Heating surface Tubes.
					Cwt.	lbs.				sq. feet.	sq. feet.
42*	Sharp and Co.	Crank axle with outside bearings.	Feb., 1844, to April 12, 1845.	40,135	11,304	31·54	137	8	8	60	476
43†	Bury and Co.	Crank axle with inside bearings.	Aug., 1844, to April 12, 1845.	14,626	5,580	35·07	109	7	10	59	595
44‡	Stephenson.	Straight axle, with outside cylinders and inside bearings.	Oct., 1844, to April 12, 1845.	18,447	4,867	29·55	67	14	1	55	998
Bodmer Engine										73	769

*April 14, 1845.—Taken into dock to have new tyres, axle-bearings, and general repairs.

† August, 1844.—Taken into dock for two new eccentric straps, and temporary repairs.

‡ April 21, 1845.—Taken into dock for new driving-wheels, new bearings in leading wheels, and general repairs.—July 10, 1845:—Taken into dock for new bearings to trailing wheels.—July 22, 1845:—Taken into dock for leading wheels keyed on to axles, and new axle boxes and bearings to driving-wheels.

In the narrow gauge inside cylinder engine there is scarcely sufficient space for the necessary repairs and cleaning; there is also a difficulty in the outside cylinder to get at the bearings, both to oil and to clean them, without lifting the engine. As a locomotive engine-maker, is in favor of a gauge of 5 feet 3 inches. There is at the New Cross station a new engine of great power made by Bodmer; he has taken out a patent not only for locomotives, but for steam engines in general, for what he calls a compensating engine, as it works with two pistons in one cylinder, so that the connecting rods pull and thrust at the same time, which takes the strain off all the other parts of the engine, except between the cylinder and the crank. The length of

the boiler is 10 feet, the cylindrical part of the boiler. The fire-box is as large as it can be got to suit the gauge. This engine has been tested against other engines and found more powerful than any other with one pair of driving wheels, because it is a larger engine, with a larger boiler, and larger cylinder; the cylinders are 16 inches in diameter, and the stroke is equal to a 30-inch stroke, being four 7½-inch cranks. It has taken 38 carriages upon an incline of 16 feet a mile, about 4½ miles long, at about 20 miles an hour, with a gross load of about 150 tons.

Cannot accurately ascertain the comparative locomotive cost of working goods trains and passenger trains upon this line, the accounts not being separately kept.

Locomotive Expenses of the Brighton, Croydon, and Dover Railways, compared with the Great Western Railway Company, for the half-year ending December, 1844.

—	Great Western Railway Company.		Brighton, Croydon, and Dover Locomotive Co.	
	Passengers.	Goods.	Passengers.	Goods.
Number of engines and tenders belonging to the Co's.	102	22	83	14
Number at work during the half-year,	96	22	77	14
Number of engines in steam each day,	35	11	25	7
Average number of miles run during the half-year,	7590	8720	6555	5252
			Passengers and Goods.	
Average cost per ton per mile,	0·15d.	0·05d.	0·182d.	
Average weight of coke per ton per mile,	lb. 0·56	lb. 0·23	lb. 0·587	
Average quantity of coke used per mile run,	34·27	51·99	34·93	
Average cost of repairs, including general charges per mile,	2·81d.	2·51d.	3·31d.	
Average cost of coke per mile run,	3·88	5·86	4·87	
Average cost of wages per mile run,	1·39	1·44	1·49	
Total cost per mile run,	9·90	12·07	11·12	

Dimensions of two engines on Brighton, Croydon, and Dover Railway.

	Diameter.	Length.	Depth.	Breadth.
Stephenson's Engine, Six Wheels. Passenger Engine, Link motion:	Ft. In.	Ft. In.	Ft. In.	Ft. In.
Cylindrical part of boiler,	3 0	12 6		
Outside fire-box,		3 8	7 8	3 8
Inside fire-box,		3 0	4 1½	3 0
Smoke box,		3 0		3 8½
Tubes, 150,	0 1¾	13 0¼		
Chimney,	1 2			
Cylinders, 1 foot 10 in. stroke,	1 3			
Driving wheels,	5 6			
Sharp's Engine, Six Wheels. Passenger Engine:				
Cylindrical part of boiler,	3 6	8 0		
Outside fire-box,		3 8	7 10½	4 2
Inside fire-box,		3 0	4 0	3 7
Smoke box,		2 1½		4 3
Tubes, 98,	0 2	8 5		
Chimney,	1 1½			
Cylinders, 1ft 6 in. st'ke	1 2			
Driving wheels,	5 6			

Distance from Centre to Centre of leading and following Axles.

Stephenson	44	Six wheeled, Passenger Engine	10 feet 3¾ in.
Sharp,	8	Ditto, ditto	11 3½
Bury,	23	Four wheeled, ditto	7 2
Bury,	39	Ditto, coupled	7 8

The passengers of an ordinary train of 10 or 12 carriages could not be changed from one train to the other under 20 minutes. With engines on narrow gauge, even with outside cylinders, there is more difficulty in getting access to the axles to clean and oil them than in the broad gauge. This difficulty of oiling the axle depends upon the circumstance of the cylinders being outside, and not upon the breadth of the gauge. It is easier to do this with the wide gauge engines; on the crank axles the bearing is taken on the outside of the wheels; on the four-wheeled engines the bearings are inside bearings, and there is a difficulty in getting the men to keep those bearings clean. If the gauge were increased from 4 ft. 8½ to 5 ft. 3, the weight of the engines would be increased from 15 cwt. to a ton. Average weight of engines on South Eastern Railway, about 14 tons; on Great Western about 17 tons. Considers that the general construction of the roads will admit of heavier engines being placed upon them.

Weight of rail upon the South Eastern line 85 lbs. a yard. The bearings average 3 feet apart upon a cross sleeper. The sleepers are triangular, they are four triangles cut out of a 13-inch square. The rails are fastened to chairs with wooden keys; and the chairs are fastened to the sleepers by wooden treenails. The boilers on the Great Western are not much larger than those upon the Brighton line. If witness had the control of the engines of the Great Western, should certainly make larger boilers. There is room to get sufficient strength and cranks, with inside cylinders; but the engine and the boiler have to be raised, which is a great objection. Would like to have the cranks more separated, and keep the boiler still the same height. To give the cranks strength, obliged to make the bearings shorter to get room for the cranks. The thickness of the side of the crank, which is perpendicular to the axis, 4 inches; some 4¼. Does not think it necessary to make that thicker; the great advantage would be in getting the bearings longer. The eccentrics are reduced as much as possible. When they are very short bearings, they are apt to heat and get dry; then they cut away the journal, and it is reduced and made weaker. With the present construction of the South Eastern Railway, should venture to increase the speed by having much more powerful engines. The quickest train is upon the Brighton line, which runs from Brighton to London in an hour and a half; that is 50½ miles, stopping once five minutes. The distance is often run in an hour and a quarter; some parts of the distance cannot be run at 40 miles an hour, on account of the gradients; and other parts have to be run at more than that speed, in order to keep the time. There are 120 engines for the three Companies, working 166 miles. This includes the Dover, Brighton, and Croydon, and two miles of branch to the Bricklayers' Arms, and the branch to Maidstone.

William Cubitt, Esq.: The limit to safe speed on narrow gauge lines is the want of evaporating surface and space for the fire-boxes, the want of solidity and perfection in the road, the want of base for engines or carriages, the want of greater strength in the rails, and greater security in connecting them with sleepers; many accidents have been caused by attempting to go too fast upon a bad road. And that danger is very much increased by increased velocity. A speed of 15 or 20 miles an hour may be safely attempted on a bad road, while double that speed would throw engines and carriages off the line of road. Attention to the state of the road has not kept pace with the improvement in the driving machine. Before increased speed is attempted that particular should be attended to. The perfection of the permanent way has been less thought about than almost any other part of railway mechanism, and that is the basis upon which it all rests. Does not think that the speed might be increased, without a corresponding increase of danger to the traveler, by adding to the width of the narrow gauge; considers the narrow gauge wide enough for safety at almost any practicable speed, but not wide enough to get the most perfect machinery for speed. An addition of 6 or 8 inches over the present narrow gauge is wide enough, perhaps, for all practical purposes of machinery of locomotive

engines and carriages. A gauge of about 6 feet would be the best. Has often heard that an increase of gauge would involve the necessity for widening the tunnels; does not concur in this opinion; if the size of the largest loads is not altered, nothing need be altered but the gauge. Does not think that if they had carriages upon a wider gauge, they would wish to carry larger loads; in railway operations would rather adopt the same width, making the vehicles of greater length, which would produce greater safety and greater convenience than by shortening them, so as to produce greater width and greater height. The adoption of a wider gauge in tunnels would not restrict the room for workmen, as regards trains passing; the wheels are always far inside the outside of the trains, and so they would be with the 6 feet gauge, because the loads are 8 feet; the only difference would be that the two inner rails would be nearer to each other, and the two outer rails would be nearer to the walls; the centre of gravity would be the same if the loads were no higher.

An increase of the width of gauge would not render it imperative to have a corresponding increase of the radius of the curves. An increase of the gauge would not render necessary a corresponding increase of the height of the driving wheel. Does not think that, in reference to the number of miles run on the broad gauge, and the number of miles run on the narrow gauge, there are fewer accidents on the broad gauge than on the narrow. The superiority of either gauge depends not upon the gauge, but upon the condition of the permanent way. Gradients are of less importance if the road is in perfect order. Rigidity in a road is preferable to elasticity in a road. With elastic rails, it becomes like driving over a series of points. If there be any elasticity at all, it is best to have it in the whole road, like having a perfect road laid upon a bog, as in Chat Moss or any other soft ground, where the whole railway itself could, in a very great length, have a very slight elasticity. There is less cost in the repair of Chat Moss than any other part of the Manchester and Liverpool Railway, on that account. It always will be so upon soft ground. If you have a good permanent way, thick enough and strong enough in itself, and lying upon a substratum, which has a little tendency to elasticity, it is most easily kept in repair. Cross-sleepers are better than longitudinal sleepers for keeping in repair. Any sleeper of a proper form can be packed, whether it lies longitudinally or transversely. There is a greater length of bearing to be obtained upon cross-sleepers than upon longitudinal sleepers. If we were to have a railway laid from end to end, all upon cross-sleepers, there would be a much greater length of bearings than upon a railway where it is all upon longitudinal bearings; and the greater number of sleepers we have the better the road will be.

Is not aware of the exact limits of contraction and expansion, by cold and heat, of a 16-foot rail; has known the road lifted up; has known it bent sideways by expansion; has never had time or opportunity to measure it exactly; it is a difficult thing to ascertain what the expansion is in certain cases; it can be done best off the line, by ascertaining the temperature of certain lengths of bar uniformly. Expan-

sion and contraction on longitudinal bearings have a tendency to loosen the screws which bind the rail to the balk.

Break of gauge is of little consequence in reference to passengers, but becomes a great difficulty in transferring heavy goods. It becomes a matter of importance to devise the best, cheapest, and quickest mode of transhipment from one gauge to the other, whether it be by removing the goods from one carriage to another carriage, or by moving the body of one carriage on to another set of wheels by mechanical power; it becomes a question of cost. The measure of the inconvenience is the cost per ton to do it quickly. The expense of constructing powerful lifting machines of little importance where the traffic is large; has laid out £130,000 to save about a halfpenny per ton upon the shipping of coals. Could put up apparatus to move 25 wagons in one minute, or in a couple of minutes, requiring the employment of not less than 50, nor more than 100 men. The cost of transhipment would be a trifle upon a long line, but a large item upon a short one. It is perfectly easy to make wagon frames and wagon bodies for a large trade that would go to any part of the country; the bodies must go quite through, and return again; the frames would keep on their own lines, and the wagons would simply drop into them. There would be no difficulty in constructing passenger carriages to move in the same way; if there is traffic enough to render it worth doing, there is no difficulty in doing it. Civ. Eng. & Arch. Jour.

(To be continued.)

TRANSLATED FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

Note on the Measurement of Water delivered through large (or wide) Orifices. By M. Morin.

I propose communicating, successively, to the Academy, the results of the experiments made by me in 1844 and 1845, at the powder mill of Bouchet, on various hydraulic motive powers; either by order of the Minister of War and with reference to the powder department, or for the purpose of examining questions submitted to the decision of the Academy itself.

In experiments on hydraulic motive powers, the most delicate portion, and that most subject to error, is the measurement of the quantity of water expended. Local circumstances, forms, or shapes, the arrangement of flood-gates, exert on that quantity great influence, which, as yet, has been too little studied, and the inexact appreciation of which has frequently led the most conscientious observers into serious errors, to which may be attributed, very frequently, the manifest exaggeration of certain results announced with the most perfect sincerity.

In order to place myself out of the reach, as far as it depended on me, of such errors, and to establish with some certainty, or at least with a sufficient approximation to it, the ratio of useful effect produced by the motive powers submitted to experiment, to the absolute amount

of water expended, I endeavored to determine upon a mode of measurement beyond the reach of controversy, which was somewhat difficult.

For this purpose, I first reflected whether I could measure, with sufficient exactness, the quantity of water supplied by an overshot-wheel flood-gate fixed at the head of a canal, or race, in which the motive powers to be subjected to experiment were to be placed.

This flood-gate is equal in width to the head-race, which is constructed of masonry; it is inclined from above downwards at an angle of about 65 degrees to the horizon; its upper edge has an acute angle up-stream, and is rounded off down-stream; it is 0·08 m. thick. Two racks, each of 0·05 m. wide, reduce the clear width to 2·017 m.

In order to estimate the volume or quantity of water that passed over this flood-gate, the tail-race, which was constructed of masonry, with a rectangular section, was closed below by a vertical dam of plank, in which were made three openings; to these were fitted wicket-gates of about 0·300 m.* square, of thin sheet iron, of about 0·005 m. in thickness, sliding in front of the orifices, which were formed with sharp edges, similar to those made use of in the experiments of Messrs. Poncelet and Lesbros. These small sheet iron wicket-gates were, by means of screws, worked by hand; rods, with marks showing the level, were placed in front of the overshot-wheel flood-gate and the wicket-gates, in order to show and to verify the invariableness of the levels.

From this short description, it may be readily conceived, that by making simultaneous observations at the overshot-wheel flood-gate, and at the orifices with thin sides, the supply, or quantity delivered, by the two kinds of orifices might be calculated, by means of the very precise results of the experiments of Messrs. Poncelet and Lesbros, and which were evidently applicable, with all desirable exactness, to the case in question.

But these experiments, undertaken on canals of great dimensions, which had vast basins, subject to the effects of the winds, and whose level it was difficult to regulate perfectly by means of an ordinary mill flood-gate, could not possess a degree of exactness comparable to that of experiments made under more favorable circumstances. In order to examine into the whole together, and to disengage the results from accidental influences, we have re-produced them by a graphic construction, taking the values of the *charge*† H, on top of the flood-gate, as abscissa, and those of the coefficient of the supply or delivery as ordinates.

In examining the table of the results, and, above all, the curve which represents them, it is seen that the values of the coefficient of the supply or delivery increase rapidly with those of the *charge* H, on the ground-sill of the orifice, from H = 0·03 m. and 0·04 m. up to H 0·10 m., a term beyond which they still continue to increase, but more and more slowly.

* The *metre*, which is the measure adopted in this paper, is equal to 39·371 English inches.

† The word *charge* throughout this paper, is intended to designate the depth of water on top of the flood-gate.

If, to compare these results obtained with a flood-gate of 2·017 m. in width, equal to that of the head-race, and placed in the beforementioned circumstances, with those which relate to a flood-gate of 0·20 m. wide, to complete contraction, we determine, by means of the figure, the values corresponding with the *charges* observed, in this last case, the following table may be formed, which we limit to the charges with which we have operated:

Width of Orifices.	Values of the coefficient m, of the formula $Q = m\,L\,H\,\sqrt{2gH}$, For the values of H equal to					
	0·04 m.	0·06 m.	0·08 m.	0·10 m.	0·15 m.	0·20 m.
0·200 m.	0·407	0·401	0·397	0·395	0·393	0·390
2·017	0·264	0·355	0·418	0·448	0·469	0·482

It is seen that for small *charges*, this flood-gate, of 0·08 m. thick, produces a notable diminution in the supply or delivery, although the contraction may be nearly annulled on the vertical sides of the orifice. This effect is analogous to that observed by Messrs. Poncelet and Lesbros on small overfalls passing through a shute. We know, in fact, that, in the cases in which the contraction is nearly null on the sides, these observers found the following values of m:

Charges on the upper side of the overfall.	0·04 m.	0.06 m.	0·10 m.	0·15 m.	0·21 m.
Values of m.	0·246	0·271	0·308	"	0·324

These values, which, for small *charges*, make a very near approach to those we have obtained, show that the diminution of the supply or delivery depends, in both cases, on the same cause, on the resistance of the side or wall of the flood-gate, or of the shute. We notice, in fact, that in small *charges*, the fluid vein wets and follows the surface of the flood-gate; but in proportion to the increase of the *charge*, this influence of the sides or walls diminishes, and soon, indeed, the fluid vein detaches itself completely from the upper edge, which is sharp up-stream, and the resistance of the surface of the flood-gate ceases to be felt, whilst at the same time the suppression of the lateral contraction continues to exert an increasing influence on the augmentation of the supply or quantity delivered; whence it results that the coefficient of the supply or delivery increases.

Such is the natural and simple explanation that may be given of the smallness of the values of the coefficient of the supply or delivery for the small *charges*, and of their magnitude for the large *charges* observed in our experiments.

Notwithstanding the care taken in the execution of these experiments, the local causes and circumstances mentioned did not permit us to approximate nearer than $\frac{1}{15}$th or $\frac{1}{20}$th; but the sketch shows,

nevertheless, by taking them as a whole, the gradual and continual progress of the increase of the coefficient of the supply or delivery, and, until new and more precise researches are made, I think we may, in applications to analogous cases, adopt with sufficient accuracy for practice, the values deduced from the sketch, for the coefficient of the supply or delivery, viz :—

Charges on the Sill of the Overfall,—in metres.

0·04, 0·05, 0·06, 0·07, 0·08, 0·09, 0·10, 0·12, 0·14, 0·16, 0·18, 0·20.

Values of the Coefficient m.,—in metres.

0·264, 0·313, 0·335, 0·390, 0·418, 0·437, 0·448, 0·460, 0·467, 0·472, 0·477, 0·482.

These values, which, for *charges* exceeding 0·10 m., are much greater than those which have been, up to this time, adopted for similar cases, show that flood-gates, arranged like that made use of by us, which is the case with many horizontal wheels, deliver more water than is generally admitted to be the case; and that, in experiments on hydraulic motive powers, we are liable, for want of a good method of measurement, to estimate the supply or delivery of water at one-sixth or one-seventh below the real amount, and, on the other hand, very much to overvalue the useful effect.

It would therefore be desirable that new, special experiments, on large flood-gates, of the proportions most in use, and arranged as is most customary, should be made with proper accuracy. The preparation and arrangement of the necessary apparatus require considerable outlay, convenient localities, and a combination of means and circumstances such as are rarely to be found, and these difficulties make us regret that the experiments already made with so much care and precision, by order of the Minister of War, at Metz, at the expense of the Government, from 1827 to 1834, with a view to the wants of the Artillery and of the Corps of Engineers, should not yet have been published, or even communicated to these corps.

Experiments on an Orifice with the Charge on the Summit.

Although the *ensemble* of the results obtained with the overshot water-wheel flood-gates, enables us to determine with sufficient exactness, at least for practice, the amount of water actually supplied or delivered in the experiments proposed, on hydraulic motive powers, I have thought it best to make use, for this purpose, of an orifice with the *charge* on the summit, so that the height, and, consequently, the area of the orifice remaining the same, the *charge* on the centre, being alone exposed to slight errors of measurement, enters into the calculation of the supply or delivery, but as under a radical of the second degree, and the influence of these errors diminishes when the *charge* increases.

For this purpose, I caused to be made on the same race or canal, an orifice of 1·496 m. in width, the vertical sides of which were 0·16 m.

and 0·165 m. from the sides of walls of the canal, and as the movements or risings of the flood-gate were very slight, when compared with these distances, the contraction might be considered as nearly complete on these sides, as well as on the upper and lower sides.

The determination of the actual supply or delivery by this orifice, was made, as has been before explained, by means of small wicket-gates, whose greatest opening was 0·300 m.

The examination of the results obtained, and above all, their graphic representation, show that the greatest deviations did not amount to more, and were almost always less than $\frac{1}{40}$th of the ordinates of the curve which represents them. And as, for experiments on hydraulic motive powers, such an approximation is quite sufficient, we have been able, in the ulterior calculations of the supply or delivery of water, to adopt the values of the coefficient of the supply or delivery deduced from this very curve.

We wish it to be observed that, in our experiments, the *charges* on the summit of the orifices having been comprised between 0·050 m. and 0·180 m. at farthest, and that this dimension, agreeably to the experiments of Messrs. Poncelet and Lesbros, producing an influence, at most, of only $\frac{1}{72}$, the variation of the coefficients has scarcely depended on any thing except the height of the orifices.

We have therefore been enabled, in accordance with this remark, to seek to compare the values of the coefficient of the supply or delivery which we have found, with those which have been determined for equal heights of orifices of 0·20 m. in width, by Messrs. Poncelet and Lesbros, and we have thus formed the following table :—

Nature of the Orifices.	Values of the coefficient of the theoretical supply or delivery for height of orifices of		
	0·20 m.	0·10 m.	0·05 m.
Orifice of 0·200 m, wide, .	0·592 m.	0·611 m.	0·630 m.
" 1·496 m. " .	0·675 m.	0·679 m.	0·727 m.
Increase owing to the augmentation of width, .	0·083 m.	0·068 m.	0·097 m.
Or .	·100 m.	·100 m.	·100 m.
	8·130	10·000	7·530

It is seen that the width of our orifice appears to have had a considerable influence on the supply or delivery, and that the increase resulting from it for this supply or delivery has varied, in the cases in question, from $\frac{1}{7\cdot 3}$ to $\frac{1}{10}$.

These results prove how necessary it was to verify beforehand the exactness of the formula to be made use of for the measurement of the supply or delivery of water, since differences of this kind might result from it.

We will moreover observe that these results, giving amounts of supply or delivery much greater than might have been calculated

agreeably to the rules generally admitted, the useful effects obtained from the motive powers studied in the experiments of which we have to give an account, will be diminished in the same proportion, and that, in this point of view, our results will be less favorable to them than if we had been content to follow the ordinary rules.

The experiments on motive powers will be the object of subsequent communications.—*(Academie des Sciences.)*

AMERICAN PATENTS.

List of American Patents which issued in the month of January, 1846,—with Exemplifications, by CHARLES M. KELLER, *late Chief Examiner of Patents in the U. S. Patent Office.*

1. For an *Improvement in the Corn Sheller;* Elijah Converse, Cincinnati, Ohio, January 7.

In this machine, the corn is shelled by the action of radial bars projecting from the surface of a horizontal disk, hung and rotated in manner similar to the runner of a mill, the ears of corn being retained to receive this action by another series of radial bars projecting downwards from the under surface of a dome-formed cap. The ears of corn are fed through an eye in the cap, and pass from thence towards the periphery of the runner, where the cob and grains are discharged. And as the dome shape of the cap gives an inclination to the series of radial bars attached to it, their outer ends are much nearer the face of the runner than their inner ends, which will adapt the machine to ears of all sizes.

Claim.—"What I claim as my invention and desire to secure by letters patent, is the before described manner of constructing the case, that is to say, with a circle of inclined radial bars on the under side of the dome, inclining downward and outward from the eye towards the base of the dome, forming, with the radial bars of the disk, a circle of triangular shaped cells for the reception and shelling of various sized ears of corn, thus doing away with the necessity of having movable concaves and boards, supported by springs to accommodate themselves to the varied sizes of the ears, which springs are liable to get out of order."

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2. For an *Improvement in the Machine for Raising Water from Wells;* Jehiel T. Farrand, Port Byron, New York, January 7.

This is for an improvement on the method of raising water from wells by means of a bucket and windlass. The bucket is hung by two ropes, one on each side, which wind around two drums on the windlass shaft, and these ropes are forced and kept out of the perpendicular by a guide-roller, so as to prevent the bucket from swinging, and the ropes from twisting together. And for the purpose of tilting the bucket, to discharge the water, the delivery spout is provided with

a hook, on to which the lip of the bucket catches when rising, and by which it is tilted, to discharge its contents into the trough.

Claim.—"What I claim as my invention and desire to secure by letters patent, is the guiding-roller, (for preventing the vibration of the bucket,) in combination with the tilting hook for emptying the bucket, and the double right and left hand ropes for suspending the same, all combined and operating substantially as herein set forth."

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3. For *Improvements in the Stove for Heating Apartments;* James Macgregor, Jr., Wilton, Saratoga county, New York, January 7.

The patentee says,—"I make the aperture for the escape of the products of combustion in the back part of the bottom plate of the fire-chamber, or in any other part of the fire-chamber, not, however, above the door for the admission of fuel and air, so that the products of combustion shall circulate freely within the chamber of combustion, above the fire, to insure the entire combustion of all combustible matter, and then escape into the chimney through the flue space in or near the bottom; there being a passage for air under the bottom plate of the fire-chamber, passing by and communicating with the flue space leading from the fire-chamber, and thence extending to the pipe or chimney; the said air passage being provided with a sliding register, or valve, at the forward part, to regulate the supply of air and draught, and ventilate the room."

Claim.—"What I claim as my invention and desire to secure by letters patent, is making the aperture for the escape of the products of combustion in or near the bottom, (not under the fuel,) and below the upper edge of the door, for the purpose and in the manner described. And I also claim the air passage below the fire-chamber, and connecting with the fire-chamber and escape pipe, or chimney, by the aperture for the escape of the products of combustion, for the purpose and in the manner described."

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4. For an *Improvement in the Straw Cutter;* Joseph C. Rich, Penfield, New York, January 7.

This is for a modification of that kind of straw cutters in which the knife is attached to a vertically sliding gate. The cutting edge of the knife, instead of being straight, is angular, running down obliquely either way from the middle, and to avoid the necessity of giving so long a stroke to the knife-gate to raise its ends above the straw in the box and passing through the feeding mouth-piece thereof, its upper edge is made with the same obliquity as the knife towards the ends, the middle part being horizontal.

Claim.—"What I claim as my invention, and which I desire to secure by letters patent, is the form of the mouth-piece, or face plate, in combination with the angular knife, as above set forth."

5. For an *Improvement in the Apparatus for Heating, Evaporating, and Concentrating Fluids;* J. J. Mapes and Wm. A. Cox, New York, January 7.

The bottom of this pan inclines in opposite directions from the sides to the middle, and just above the two inclined surfaces of the bottom, there are two series of parallel pipes, each series communicating at either end with a pipe at right angles, the one along the side of the pan to conduct steam to the upper end of the series of pipes opening into it, and the other near the middle to receive and discharge the steam and water from their lower end.

Claim.—"We claim the employment, within an evaporating pan, of a series of inclined tubes, in combination with an upper and lower box, or tube, the former communicating with the upper end of the series of inclined pipes for the admission of steam to them, and the latter with the lower end of the series, for the discharge of steam and water produced by condensation, substantially as described."

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6. For an *Improvement in the method of Glazing Cotton Battings;* Darius Goff, Rehoboth, Massachusetts, January 15.

Claim.—"I wish it to be distinctly understood that I do not lay claim to this apparatus as it has been employed for saturating, with tar and other similar substances, battings made of hempen and other coarse fibres employed in sheathing vessels, &c., the object being thoroughly to saturate the fibres, to cause them to adhere to each other and to the cementing matter, with the view to form, as near as practicable, a water-proof fabric, the object and the fabric being entirely different from cotton or pelisse wadding; but what I do claim as my invention in the process of glazing the fabric known under the general appellation of pelisse or cotton wadding, is passing it through the glazing liquid at a velocity substantially as described, so as to cover the entire surface and edges without penetrating to the inner fibres, as described."

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7. For an *Improvement in Clocks or Time-Pieces;* Thos. A. Davis, New York, January 15.

This is for making use of the weight of a clock and case as a substitute for the weights heretofore employed to carry the movement and striking part, which is effected by carrying the cords from the two driving drums up through the upper part of the case and uniting and hanging them over a loose pulley, so that the weight of the clock is hung to the cords, which, passing over a loose pulley, will always keep it balanced, irrespective of the motion of the two movements of the clock.

Claim.—"What I claim as my invention and desire to secure by letters patent, is suspending the case and parts of a clock or time-piece, as above described, in such a way as that the weight of the same will cause the working parts to go in the usual way, thereby saving the

expense of the ordinary weight and springs as the motive power. I also claim the introduction of the pulley, as herein described, to regulate the weight between the time and strike sides."

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8. For an *Improvement in the Bee Hive;* Harvey W. Sabin, Gorham, New York, January 15.

The patentee says,—"The nature of my invention consists in forming the honey boxes so that all the sides can be readily detached, (they go together with dowel pins, or other suitable contrivance,) so that said boxes can be lined with paper around the sides and bottom that is easily removed with the honey, the top of the box has a thin board under it, on which the comb is formed.

Claim.—"What I claim as new and desire to secure by letters patent, is constructing the honey boxes so as to be taken to pieces, in combination with covering them, in manner described, with paper, for the purposes set forth, having an additional or false top, on which the comb is to be built."

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9. For an *Improvement in the method of Constructing India Rubber Boats or Pontoons;* Horace H. Day, New York, January 15.

The patentee says,—"My improvement consists in forming the boat of a sheet of India rubber for the bottom, extending around and attached to hollow cylinders of India rubber cloth, connected together by their ends to form the outer frame, or what corresponds with what are termed the 'gunwales' in ordinary boats."

Claim.—"I am aware that boats and pontoons have been formed of inflated cylinders of India rubber, connected together side by side, to receive a platform above them; and also that the outsides of boats have been made of India rubber cloth, distended by means of a wooden frame placed within; and therefore I wish it to be distinctly understood that I do not claim as my invention simply making boats of India rubber cloth, either with or without inflated cylinders; nor do I claim simply making boats with hollow air-tight vessels around the gunwales, as this has been resorted to in life-boats made of wood or metal; but what I do claim as my invention and desire to secure by letters patent, is making boats of a sheet or sheets of India rubber, or other water-proof cloth, attached to a frame consisting of inflated India rubber cylinders, in manner substantially as herein described."

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10. For a method of *Softening India Rubber, and preparing it for Grinding;* J. W. Harmon, New York, January 15.

Claim.—"What I claim as my invention and desire to secure by letters patent, is the softening of India rubber preparatory to grinding, by the use of the vapor of either turpentine or naphtha, combined with steam, as described."

11. For an *Improvement in Cooking Stoves;* Benjamin F. Dewolf, Lansingburg, New York, January 15.

Claim.—"What I claim and desire to secure by letters patent, is the horizontal passage between the outer plate of the oven and the inner bottom plate of the baking apartment, with the openings in and out of the same, together with the provisions by which the fire and heated air from the fire-chamber are made to pass through the same, in the manner and for the purpose described."

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12. For an *Improvement in Bridges;* Thos. Hassard, New York, January 15.

The nature and object of this improvement will be clearly understood from the following

Claim.—"Having thus described the manner in which I construct my bridge and arrange the respective parts thereof, what I claim therein as new, and desire to secure by letters patent, is, first, the manner in which I combine the braces with the cord timbers, by means of the shoes and the caps attached to the posts, the shoes admitting wedges for keeping up the structure, and the whole combination being such as is set forth.

"I do not claim the use of cast iron shoes, such having been used to receive both the vertical posts and the braces, and not being capable of effecting the purpose for which I employ them in combination with posts that pass through the upper and lower cords."

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13. For an *Improvement in the Bedstead Fastening;* Ebenezer F. Gazzaw, Pittsburg, Pennsylvania, January 23.

This is for an improvement in the method of fastening into the posts of bedsteads the metal plates which form the fastening for the rails, which is effected by making that part of the metal plate which is inserted into the post with a groove all around it, into which are laid strips of wood, so that the plate or nut can be secured by glueing,—the strips of wood being secured to the mortise in the post by glue, and the plate held to the strips by its flanches.

Claim.—"What I claim as my invention and desire to secure by letters patent, is the projection, or nut, on the inner surface of the plate now in use, and the peculiar arrangement, above described, of the wooden slats or strips, by means of which, the plate may be permanently fastened into the post with glue, thus saving the cost of screws and the time necessary to put on the plate by means of screws, and at the same time making a more complete and permanent fastening.

"I do not claim as mine the method of fastening the rail to the post, of which the plate described constitutes a part, but merely the above described method of fastening the plate itself into the post."

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14. For an *Improvement in the Washing Machine*; Moses Chase, Baltimore, Maryland, January 23.

We are under the necessity of omitting the claim in this case, as it

refers to and is wholly dependent on the drawings. The improvement consists of a combination of parts for operating a pendulous dasher, which vibrates within the wash box, and at the same time giving a vibratory motion to hinged flaps on each side of the dasher, that the clothes may be acted upon by the joint action of the dasher and these hinged flaps, and between them.

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15. For a *Vegetable Composition* to be moulded into various articles, such as handles, heads, &c.; Charles Branwhite, New York, January 23.

The following is an extract from the specification:—

"Take half a pound of starch and dilute it in one pint of cold water, then put one quart of water in a gallon open vessel, and let it boil,—then pour the diluted starch into the vessel, and when it again boils add 3 pounds of rye flour, and stir it well while on the fire, until the whole is well mixed together. When this mixture is cold take it out of the vessel and place it on a flat surface. Now take finely sifted dry mahogany saw-dust, (or, finely sifted wood ashes, or whiting may be used,) and stiffen the dough to the consistency of good putty, by working the whole together well with the hands. The composition is now ready for use."

Claim.—"What I claim as my invention and desire to secure by letters patent is the before described vegetable composition, for the purpose of making moulds, heads, and handles of every description, especially in the making of fringe and tassel moulds, parasol and umbrella handles or heads."

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16. For an *Improvement in the Machine for making Hat Bodies;* Wm. Fosket, Ware, Massachusetts, January 23.

In this machine, the fibres are to be deposited on a perforated or wire gauze former, or cone, by exhausting the air from the inside, the case being placed in a chamber in which the fibres of fur or wool are introduced by an endless apron, and thrown up by a bow.

Claim.—"Having thus explained my invention, I claim the combination with the wind chamber surrounding the conical frame of gauze, of the apparatus which feeds the fibrous material into the chamber, and whips, or prepares it, previous to its reception therein, the said apparatus consisting of the feeding apron, with its spring plate and bow-string; the whole being arranged and operating substantially in the manner as above specified and described."

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17. For an *Improvement in the Double Seaming Machine for making Tin Ware;* Joseph V. Hewes, Putnam, Indiana, January 23.

Claim.—"What I claim and desire to secure by letters patent, is the giving to one of the double seaming rollers a conical flanch, in combination with a spring attached to the shaft of said roller, in such manner that the flanch surrounding the bottom of a vessel can be gra-

dually bent down, and the seam perfectly finished at one operation, the parts being constructed and combined substantially as set forth."

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18. For an *Improvement in the Elevated Oven Cooking Stove;* Lathrop S. Bacon, Genesee, New York, January 23.

The flue around the elevated oven is divided into two parts by a partition, and the vertical flue leading thereto is divided into two parts by a vertical partition; one of the divisions having a pipe leading into the chimney, and each provided with a damper, so that the draught can be discharged directly into the chimney, or be carried around the oven first.

Claim.—"What I claim as new therein and desire to secure by letters patent, is the dividing of the wide elevating flue of the elevated oven, and of the flue space surrounding said oven, into two compartments, by the partition plate, in combination with the dampers and the exit opening in the flue; the whole being arranged and operating substantially as herein fully made known."

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19. For an *Improvement in Transparent Covers for Stoves, Grates, Heaters, &c.;* Henry C. Billings, Trenton, New Jersey, January 28.

This is for making transparent covers for stoves, by means of two perforated plates that rotate on each other, that the solid parts of one may close the apertures in the other, in the well known manner of making registers; a plate of mica being interposed between the two metal plates.

Claim.—"I expressly disclaim the use of mica with register plates, and intend only to claim as my invention the manner of combining the plates, and plate of mica with the plates, arranged and operating in the manner set forth."

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20. For an *Improved method of Cutting out Ladies' Dresses;* Hiram Seger, Macon, Georgia, January 28.

The patentee says,—"The nature of my invention consists in forming a couple of patterns: No. 1 being the shape of one half the front of the bodice of a lady's dress, from the centre of the front to a seam descending from the lower part of the arm-hole; and No. 2 being a pattern for one half the back of a bodice from the seam under the arm to the centre of the back. These patterns are laid off with scales, with holes through the same, the scales being placed in such positions, and the openings in the same for dotting through on to the cloth, being placed at such distances that the patterns can be reduced to suit persons of every size, and preserve the shape and proportions of the patterns, and adapt them to every shape and size of form of person."

Claim.—"What I claim as new, and desire to secure by letters patent, is the form of the patterns, Nos. 1 and 2, and the arrangement of the graduating open scales upon the same, for adapting the patterns

to persons of different sizes, constructed and operating substantially in the manner and for the purpose set forth.

"I also claim the manner of applying the several measures taken in obtaining the size of a lady's form, by means of the patterns and scales, so as to shape the different parts of the body of a dress, substantially as set forth."

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21. For an *Improvement in Washing Machines;* Chas. King, Scipio, New York, January 28.

Claim.—"Having thus fully described my improvement, I wish it to be understood that I do not claim carrying the clothes around between a double series of rollers, placed in a circular form, as that has before been essayed; but what I do claim as my invention and desire to secure by letters patent, is the combination of a stationary set of rollers, placed in a cylindrical form, with a cylinder of rollers moving around within them, and having a play by means of the elastic springs, whereby the clothes are more perfectly washed, and remain uninjured during the process."

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22. For an *Improvement in Coloring Daguerreotype Plates, by fixing the Colors thereon;* Frederick Langenheim, Philadelphia, Pennsylvania, January 30.

The patentee says,—"In the invention of Isenring, for coloring plates, for which letters patent have been obtained, a difficulty arose in making the colors adhere, and it was found in practice that after a little handling, the color came off, and the picture was thus defaced. To remedy that defect is the object of my improvement.

"Either before the plate receives the color, or at the same time, I cause an impalpable powder of gum damarum, or other suitable resinous gum, to cover the parts to be colored, in the manner described in the patent granted to me as the assignee of Isenring, viz: by placing the plate in a close vessel, face up, with those parts covered that are not to be colored, and then filling the atmosphere contained in said vessel with the powder of gums above named, and allowing a sufficient quantity to settle, for the purpose intended; after the color is laid on the plates I submit it to a sufficient degree of heat to fuse the gum, which causes the color to adhere."

Claim.—"Having thus fully described my improvement, what I claim therein as new and desire to secure by letters patent, is fixing the colors on the plates by means of gum, applied substantially in the manner and for the purpose set forth."

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23. For an *Improvement in Coloring Daguerreotype Plates;* John B. Isenring, of Switzerland, assigned to Frederick Langenheim, Philadelphia, Pennsylvania, January 30.

The patentee says,—"The nature of my invention consists in coloring a daguerreotype picture by agitating a quantity of highly pulver-

ized mineral, or other suitable color in a box, and then placing in said box the plate to be colored, having only such parts exposed as are to receive the color, the rest being covered by a stencil or other similar device, where it remains until the color settles upon it in sufficient quantities."

Claim.—"What I claim as my invention and desire to secure by letters patent, is the process of depositing the color thereon, substantially as herein described, by causing the finely pulverized particles of color to float in the air over where the plate is placed, which, as they settle, are deposited on the uncovered portions of the plate, in the manner and for the purpose herein described.

"I also claim, in combination therewith, covering the picture with a stencil, as set forth, constructed in the manner and for the purpose described."

BIBLIOGRAPHICAL NOTICE.

Dr. Gardner's Memoir upon the Chemical Principles of the Rotation of Crops.

The Chemical Principles of the Rotation of Crops, a Memoir pronounced before the American Agricultural Association, March 4, 1846, by D. P. Gardner, M. D., Honorary Consulting Chemist of the Association. member of the Lyceum of Natural History, etc. Formerly Professor of Chemistry and Natural Philosophy, in Hampden Sydney College, Va.

The Essay with the above title has been published in the transactions of the American Agricultural Association, of which it occupies seventeen quarto pages. The subject is treated in a scientific, though very lucid manner, the main object being to point out and establish principles without dealing in nice details. Dr. Gardner has succeeded in condensing a very great amount of useful information in a small compass. He sets out with explaining the objects and necessity of rotation, and gives the views that have recently prevailed in relation to what is termed a natural rotation. Upon this last subject he says:

"The natural succession of plants is connected with the presence of organic matter in the soil. The richest weeds which first occupy the surface having the greatest necessity for it, and thus through successive groups to the grasses and forest trees which grow well without any portion in the soil. Other elements of fertility being present, the Chenopodiaceous and allied families thrive only in such localities as yield azotized matters, since they cannot grow without a supply from the soil. This surmise is not only sanctioned by the obvious presence of organic matters in the soils where they grow, and by the fact that some species exhale ammoniacal gases, but it is fully established by the experiments of Boussaingault. This chemist grew clover, peas, wheat, and oats in a soil completely destitute of organic matter and supplied them with distilled water only; the clover and peas were found to double their azotized matter during growth, whilst the oats and wheat gained none whatever. As there was but one source of

azote present, the atmosphere, it is apparent that the former have the capacity of supplying themselves therefrom, whilst the grain plants are altogether dependent on the soil. Hence in a soil charged with organic matters, rich in azote, those plants which require a supply by their roots will grow freely, and so far exhaust it in time as to render it unfit for the species, which is succeeded by an intermediate class, and finally by the Graminæ, Leguminosæ, and others capable of subsisting on aerial azote, and so far from exhausting, adding it to the soil. From this function of plants, we see an explanation of the natural rotation, and what is of more moment, a means of adapting our succession of crops to the accumulation as well as removal of azotized matters."

By most of the French scientific agriculturists, including Boussaingault, and Payen, the value of manures is estimated according to the amount of azote they contain. With them, therefore, the great object of manuring is the application of azote to the soil, and the great, if not the sole, principle in rotations is the economy of this body. Crops are to be introduced in such order that after the application of the manure a highly exhausting plant as wheat may come, and this be succeeded by others of less affinity for nitrogen, and again by those which draw their supplies from the air and are the ameliorating crops of this class of agriculturists. The soil now recruited by clover, lucern, grass, etc., will bear another azotized crop, and the system is at an end.

There is something charmingly simple and plausible in this "one principle rotation," as Dr. Gardner terms it. But, he remarks, our corn, wheat and oats not only draw azote from the soil, but other bodies, namely, the inorganic and saline matters, much more of which is often withdrawn, than of azote. He refers to a paper read by him before the Association the previous year, containing the results of a thorough examination made by him into the nature of the exhaustion of lands by seed crops. The object of that communication was to prove the following points:

"1. That all seeds contain an excess of phosphoric acid, amounting usually to thirty-five or forty per cent. of the entire ash, nearly the whole of the ash being in many cases phosphates; this was demonstrated in the case of corn, wheat, beans, hemp seed, flax, peas, cotton, and other plants. It was also shown that the straw and haulm seldom contain more than one to three per cent. of phosphoric acid, this substance being segregated in the seed. For the analytical evidence of these positions I beg to refer to the Farmer's Dictionary, in which the admitted analyses of all plants hitherto examined will be found.

2. "That phosphoric acid is the least developed of all the mineral bodies of the soil, being seldom present to the extent of 0.5 per cent., and usually less than 0.1 per cent., in good soils.

3. "That many soils containing from five to twelve per cent. of humus are known to be steril.

4. "That the amount of phosphoric acid removed by given seed

crops far exceeds that removed by the ordinary forage crops, being often five times as great.

"The evidence of these positions was set forth at length in that communication and is therefore not worthy of repetition. The principle which I believe was fairly reached, and admitted, was that seed crops exhaust the soil of phosphoric acid—the deprivation of which is easily perceived, even in the best lands. It is not necessary for me to advance further evidence of this fact before your Association.

"If it be admitted that phosphoric acid is segregated in the seeds, it is evident that the exhaustion effected by foliage plants, as tobacco, cabbages, flax, hemp, etc., not intended for seed and of the root crops, with perhaps the exception of turnips, is due to another cause. The experiments of BOUSSAINGAULT and our own observations on natural rotations will now throw light on this other kind of exhaustion. Some plants draw all their azote from organized matters in the soil, others from the air: some families of plants appear only on rich soils and around dung-hills, while others inhabit the mineral earth destitute of organic matters. It is evident that phosphoric acid has nothing to do with this peculiarity, for none is removed from the soil, the dead plants restoring it; there is a diminution only in volatile matters or in the azotized products of the decaying organic matter. Let us cultivate a few crops of cabbages or tobacco on a rich spot of land, how soon will the organic matter disappear! Practical men may tell us that this is because the crops are hoed and the soil exposed to the sun, but this is not the cause; the hoeing improves the plant because by introducing air it hastens the decomposition of the organic matters of the soil or assists the fixation of atmospheric nitrogen. (*See Mulder Journ. für. Pract. Chem.* XXXII. p. 344). When putrescent manures are added to tobacco, potatoes and similar crops, the indication is to furnish azotized matters, and is altogether different from the object in view when it is added to wheat and certain grain crops. But if this point requires further evidence we may appeal to those plants which exhaust the soil differently under different circumstances. A flax crop raised for its fibre exhausts the soil of azote and may be followed by corn or beans, but if it be allowed to mature seeds it exhausts the soil doubly of azotized matter and phosphoric acid, and cannot be succeeded by corn except in the richest soils. Hemp raised for fibre may be cultivated many years in a soil containing much humus but the seed crops are rapidly exhausting.

"Hence we have crops which exhaust the soil of azotized matters—crops which remove an excess of phosphoric acid—and grasses and clovers, cut before bearing seeds, which exhaust the soil of neither of these essential bodies but on the other hand enrich it in organic matters. Many cultivated plants, as corn, wheat, cotton, hemp, flax, cabbages, etc., raised for seed, exhaust in both respects and are therefore peculiarly expensive crops. With this amount of information, based on experience and several hundred analyses, we have the means of rendering intelligible the precepts of practical writers on the succession of crops.

"Precept first resolves itself into the principle, that plants exhaust

the soil unequally in respect to azotized matters and must therefore be so adjusted that the most exhausting should recur as seldom as possible.

"Precept second. Seed crops, which exhaust the soil of phosphoric acid, are to be interchanged with herbage plants, which do not remove as much of this important substance.

"These directions have now assumed a definite form and are an explicit guide to the well informed farmer; he at once perceives that there are, over and above the precepts of expediency as to hoed or cleaning crops and deep rooted crops, classes of plants which differ remarkably from each other in their action on his fields. 1. Seed crops which exhaust the soil of azote. 2. Seed crops which do not exhaust the soil of azote. 3. Exhausting forage and root crops. 4. Crops which neither exhaust the soil of humus nor phosphates, but renovate the azote. With this amount of knowledge he can shape a fair system of rotation, whatever may be his crops—he can introduce indigo, cotton, tobacco, corn, bene, oil plants, and many others which are not found in the arbitrary tables given by Low, Thaer, and Stephens, or falsely placed by Buel and Armstrong. But if we recur to our definition of the object of a rotation—the production of the greatest profit in crops, with the least exhaustion of the soil or manure—we find that there is yet something wanting in the principles of rotation. In the fourth class above, we have plants which neither exhaust the soil of azote nor phosphoric acid; it now becomes necessary to know in what respect they do exhaust it, so as to satisfy the economical condition of impoverishing the soil in the least degree."

In addition to the well known affinity of plants for phosphoric acid, without which they cannot ripen their grain or seed, chemical analyses, now extended to several hundred subjects, show the precise substances or alkaline bases taken up by different individuals. The classes which prefer *potash* are the composite, umbelliferous, amentaceous, gramineous, and chenepodiaceous; those which most affect *lime*, are the leguminous, rosaceous, solanaceous, and rubaceous; those selecting *soda* are the families of crucifera, asphodelœ, and liliacea.

In thus grouping plants with relation to the mineral bases which they most affect, it is necessary to bear in mind the existence of what has been termed an isomorphism amongst many of the mineral bodies. Isomorphism may be defined the connection between the external form and the chemical composition of bodies. Isomorphous substances are those which possess the property of mutually replacing one another in combinations without varying the form of the same. Thus—potash, soda, oxide of ammonium, and hydrate of lime—lime and magnesia—sesqui-oxide of iron, sesqui-oxide of manganese and alumina—sulphuric and selenic acids—phosphoric and arsenic acids—are respectively enumerated as isomorphous groups, that is to say, soda may replace potash; hydrated or slaked lime may be present in place of either soda or potash. In proof of this, soda has been found by chemical analyses to replace potash in the ashes of the oak on the sea coast of Long Island. Grapes cultivated near the low salt

plains of New Jersey have been found to contain soda instead of potash. On the other hand, marine plants transplanted to an interior situation are found to contain potash. Tobaccoes from various sources, analyzed by Berthier, yielded potash as a base, whilst specimens examined by Fresenius and Will, yielded 60 per cent. of lime and magnesia.

It must also be observed that the different parts of the same plant yield an excess of dissimilar salts. The potato tuber contains 80 per cent of potash,—whilst analysis of the tops gives 61 per cent. of lime. Chemical examinations of different plants will therefore show different results with the same plant raised upon different soils, or at different times in the same soil. The French government agents, finding a great depreciation in the tobaccoes imported from the United States, set about an investigation, which resulted in showing that in the place of the salts of potash formerly obtained in the good specimens analyzed by Berthier, the salts of lime predominated in the inferior specimens of more recent growth.

Dr. Gardner thinks that in determining the place of a plant in the saline groups, the ashes of the leaves should be selected as the true guide, chiefly because the leaf is the important organ of vegetation in which the sap is elaborated, and the future growth of the plant provided for. If the view of Raspail be correct, that the presence of saline matters in tissues, is the essential of their organization and true source of their distinction from the mere proximate principles of which they are composed, it is a necessary consequence that the organizing portion of the plant—the leaf—should contain the essential saline matters, without which, or other isormorphous substitutes, it could not be developed nor carry on its functions; and if the leaf does not flourish, the plant cannot attain perfection.

With regard to the influence exerted upon plants by cultivation, Dr. Gardner observes,—

"Under natural circumstances all the grain-bearing plants require little azotized matter, but from the development which many, such as wheat and barley, have acquired, they have become azotized plants, and are not to be maintained in their present state without a large supply of this food made to the roots. Many garden vegetables are also of this kind; the cabbage in nature consists of a few tough leaves and inhabits soils of ordinary fertility on the sea side; its present luxurious development, by which it attains a weight certainly a hundred times greater in several varieties, is the result of supplying food to the root in tillage, and if the supply be diminished the characters of the variety are soon lost and the vegetable degenerates.

"The following table will show the position of most cultivated plants, so far as evidence exists at present. The conditions under which the classification has been made should be borne in mind.

- Plants requiring much azote in the soil,
  - Seed bearing,
    - Lime, — Hemp seed, Cotton, Hop, cultivated Peas,
    - Potash, — Corn, Madia, Wheat, Rice, Oats, Barley.
    - Soda with Sulphur, — Rape seed, Colza, Mustard seed, Linseed.
  - Foliage or root crops,
    - Lime, — Tobacco, Potatoes, Hemp, Indigo, Madder.
    - Potash, — Sugarcane, Carrots, Parsnips, Mangel-wurzel, Beets, Spinach.
    - Soda with Sulphur, — Turnips, Kohlrabi, Ruta baga, Cabbages, Onions, Asparagus.
- Plants requiring little or no azote in the soil,
  - Seed bearing,
    - Lime, — Field Beans, Pindars, Vetches.
    - Potash, — Rye, German and Polish Millet, Buckwheat.
  - Foliage or root Crops,
    - Lime, — Pomaceous fruits, Lupius for fallowing Clovers, Spurry, Lucern, Sainfoin; all cut before seed.
    - Potash, — Meadow Grasses, Jerusalem Artichoke.

"Thus the table presents ten groups of plants to be employed in a rotation, which are variously exhausting of saline matters, and exhausting or ameliorating as respects azote."

The fitness of a farm to produce remunerating crops may, for the most part, be estimated from an examination of the preceding table. In converting the minerals of the earth into crops, we must adopt such a system of rotation as will not exhaust the bases of fertility too rapidly, without compensation from some source. If, in a situation where every product is marketable, we adopt a series of rotation in which the crops draw from the earth only phosphoric acid, the purchase of azote, lime, potash, and sulphur, would be of no advantage but, on the contrary, just so much money spent unprofitably. By a judicious succession of crops however, each fertilizing agent in the soil may be converted into money without loss or improvidence.

"As," in the language of Dr. Gardner,—"we have paid for every kind of plant-food in the earth, we incur a loss by allowing any part to remain unappropriated.

"The farm having reached its high point of tillage, by suitable means, is now to be cropped for profit, and reduced thereby to a practical standard—what are the general principles on which this cropping is to be conducted? Obviously by a system of rotation, during which every saline and azotized matter that becomes soluble is removed, and no part is wasted. This can be accomplished only by introducing such crops as have severally an affinity for the various kinds of plant nutriment, and adapting them to the proportion of food present in the soil. Phosphoric acid is the rare ingredient of soils and manures, excepting guano and bones, the former of which contains

12 and the latter 25 per cent. of this body. Next after this is the azotized matter which forms a small per centage of vegetable mould (0. 5 to 3. 0 per cent,) and is therefore to be removed cautiously. Sulphuric acid is present to some extent in all soils, abounding most in ancient marls and gypseous formations. The supplies of lime and alkalies are very much greater than any of the preceding bodies; the former attaining 10, and the latter 4 to 5 per cent. in rich alluvial lands. The extent to which we may remove these in a rotation is as their probable amount in the soil, which may be taken in general terms after the following rates per cent. in a perfect alluvial soil. Phosphoric acid 0. 20—azotized matter 0. 25—sulphuric acid 0. 10—alkalies 2. 00—lime and magnesia 5. 00. In estimating the consumption we must know the amount and kind of bodies removed with each crop. The difference of average crops in this respect is remarkably striking, and the subject has been fully detailed in my lectures in the University. It may be proper, here, to adduce by way of illustration, a few cases. A crop of wheat of 25 bushels with straw removes 123 lbs. of inorganic matters, consisting of about 12 lbs. of phosphoric acid, 90 lbs. of silica, 15 lbs. of alkaline salts. A crop of lucern of two tons removes 425 lbs. of mineral bodies, of which about 250 lbs. are lime, 20 lbs. sulphuric acid. Eight hundred bushels of beets remove about 360 lbs. of ashes, of which 316 lbs. are alkaline salts.

"It would be tedious and out of place to read here the tables upon which these calculations are made; it may be enough to state that they have been made, and that they form one of the necessary items of knowledge in constructing a perfect rotation. In addition to this, every expedient used by practical men, as the introduction of cleaning crops, green fallows, depasturing fall crops, the employment of roots, etc., are to be attended to in carrying out the design of the rotation—the economy of the mineral and organic aliments of the soil."

Dr. Gardner pays a just tribute to the Norfolk system of rotation, the general adoption of which in many parts of England has raised entire counties from sterility to the highest state of prosperity. "It consists of the following succession: first year, manure, followed by turnips; second year, barley sown with clover; third year, clover, the first crop cut, then depastured and ploughed for wheat; fourth year, wheat, succeeded by manure and turnips, as before. In this system the manure is followed by the plant requiring the most azotized matter. It is also a soda and sulphuric acid crop. Barley, the second crop, requires very much less azotized matter and exhausts the soil of only a limited amount of phosphoric acid and potash. This is succeeded by a lime plant, clover, which recruits the azotized matter and loosens the soil by its long roots. Wheat, which completes the rotation, is a potash and phosphoric acid crop, requiring a medium supply of organic matter. This rotation, when we consider the soil and the manures used, the former siliceous and the latter farm-yard compost and bone earth, is a perfect embodiment of the foregoing principles. Reached entirely by experimental means, it is strictly conformable with science; and is a striking illustration of the correctness of the

doctrine, that rotations form a chemical study, which, originating with CHAPTAL, has been maintained to our day."

He concludes his highly interesting memoir by presenting examples of five year rotations, adapted to peculiarities of soil, etc., in the United States. The plants he proposes for the several soils are indicated by the probable excess of mineral matters and phosphoric acid therein. "The crops which may be substituted are placed vertically under the principal plant. There is in the rotation for clay soils, a mechanical impediment, arising from the difficulty of keeping them in tilth, which influences the plan; and in sandy soils, also, it is necessary that too many hoed crops be not introduced, and that grazing be practised to render the soil compact. The rotations given are applicable north of Carolina."

I. *A Rotation for Good Mixed Soils.*

	First Year.	Second Year.	Third Year.	Fourth Year.	Fifth Year.
Manure—or the soil in the highest condition.	Corn.	Oats, Rye, Barley. Clovers, Grasses.	Clovers, Grasses.	Potatoes.	Wheat, Oats, Barley. Carrots, Parsnips.

II. *A Rotation for Rich Calcareous Soils.*

	First Year.	Second Year.	Third Year.	Fourth Year.	Fifth Year.
Manures, etc.	Potatoes, Hemp, Tobacco.	Wheat, Barley, Clovers.	Clovers.	Corn, Beans.	Oats, Rye.

III. *A Rotation for Rich Siliceous Soils.*

	First Year.	Second Year.	Third Year.	Fourth Year.	Fifth Year.
Manures, etc.	Turnips, Rutabaga, Beets, etc.	Rye, Grasses, Oats, (Spurry,) Barley.	Grasses fed off, (Spurry,)	Corn, Wheat, Buckwheat.	Jerusalem artichoke, Rye.

IV. *A Rotation for Clay Soils.*

	First Year.	Second Year.	Third Year.	Fourth Year.	Fifth Year.
Manures, etc.	Corn.	Oats, Clover, Rye, or Grasses.	Clover, Grasses.	Potatoes, Beets.	Wheat, Barley, Oats, Beans.

MECHANICS, PHYSICS, AND CHEMISTRY.

TRANSLATED FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

On the Manufacture of Metallic Pens.

Although millions of metallic pens are consumed in Europe and other parts of the world, yet the manufacture of them is little understood, and almost exclusively carried on in England.*

The principle of this manufacture is extremely simple, nevertheless, the operations necessary to bring this small article to the state in which we see it, are more complicated than we should be led to expect. The following is the information on the subject which we have been able to collect:—

The material of which metallic pens is made, consists, in general, of plates of steel of the same thickness as that of the pen when finished. These steel plates are from 1·25 m.† to 1·50 m. long by from 0·60 m. to 0·90 m. wide. They are cut by a machine entirely similar to that used for cutting the paste-boards for Jacquard looms, into bands or strips, the width of which is about double the length that each pen should have when finished.

These strips are taken to the cutting-press, which nearly resembles the fly-press used in coining, but is smaller and more simple. A young girl takes, with the left hand, one of the loaded levers of this press, and with the right hand pushes successively the metallic strips on to the die or matrix of the press.

When this operation is completed, the work-woman strikes a blow with the press, which cuts out many blank pens at a time, these are so placed in two rows, that the point of one of the pens of the one row is cut out of the interval that separates two adjoining pens of the other row, and so reciprocally. The die which lies below, and the counter-die, which the screw of the press successively raises and lowers, have forms corresponding to the number and pattern of the pens that are to be cut at one blow. As soon as the blow is struck, the work-woman draws back the lever, the cut-out blank pens fall into a box placed to receive them; the work-woman pushes on the strip of steel, and the same operation is repeated.

A young girl can, in this manner, cut out 300 blank pens in a minute.

The pens, in this state, are taken to another work-woman, whose business it is to pierce the hole which they are to have near their centre. This hole is made by a press exactly like that used to cut out the pens, but smaller. The piercer, or punch, has the shape of the hole intended to be made, and the matrix has a corresponding cavity.

The blank pens just cut out, being placed to the left of this work-woman, she takes a certain number of them in her right hand, which she

* *Note by the Translator.*—The manufacture of metallic pens is carried on extensively in the United States.

† The *metre*, which is the measure adopted in this paper, is equal to 39·371 English inches.

nolds by the fingers by the widest part, opposite to the point; she introduces this point between the dies, until she meets with a resistance caused by a stopper, she then adjusts it, fixes the pen in its place by means of a small elevation on the counter-die, so arranged, as that not only the point, but also its oblique edge, exactly fit it, and the pen is placed in a fixed and determined position under the screw of the press. In this position, the work-woman strikes the blow with the fly-press, pierces the hole, and whilst, with the same hand, she draws back the lever, with the right she throws to the same side the pierced pen, which had been held firmly during the operation, and immediately, with quickness and dexterity, replaces it with another, which is to be similarly treated.

These pens, thus pierced, pass into the hands of a third work-woman, who makes the two lateral slits, which give them the necessary elasticity. This operation is performed exactly in the same manner as the preceding.

Among all the before mentioned operations, none presents more difficulties than the cutting or sinking of the dies and counter-dies, and their adjustment in the press. These require, in fact, much ability, care, and exactness; but when once good tools are prepared, the manufacture may go on steadily, furnishing products of a good quality, and always of the same pattern.

The next process is to round the pens, that is, to give them a semi-cylindrical form. For this purpose, the counter-stamp has a cavity corresponding to the shape which the pen is to have. The work-woman takes the pens and pushes their open and slit extremities as far as a stopper will permit, on to this counter-stamp, and then, by means of a blow of the press, brings down the stamp, which is so shaped as to give the pen the necessary curve.

As soon as the pen has received the proper curvature, the slit at the point, which causes the ink to flow, must be made. This delicate operation is little known, and many persons have, till now, supposed that it was performed by stamping, exactly as in the usual way, that is, by means of a kind of blade or knife, which, after having cut the slit in the pen, was to enter into a corresponding slit in the counter-stamp; but it would appear, on the contrary, that it is effected by tools which operate rather like the blades of a pair of scissors, than like parts of a stamp, properly speaking. The counter-stamp, in this case, acts as one of these blades, whilst the stamp takes the place of the other. Between these blades, the blank pen is fixed in a proper position to make the slit, which is cut rather successively, than slit, and the piece taken out at a blow.

When the pens are brought to this state, we are assured that to smooth off the too-sharp edges, they are filed by hand with fine files by some manufacturers, whilst others roll them in parcels in the powder of emery, or other hard stones. Finally, it appears to be certain that the points are smoothed and rounded off on a hone, or rather on a soft grindstone, in order that they may not tear the paper.

However this may be, when the pens have acquired the necessary perfection, they are thrown in a mass into a cast-iron pot, in which

they are heated in a furnace to redness; in this state, they are immediately plunged into a vessel containing a composition into which gum lac enters. After remaining twenty-four hours in this composition, they will have received the required color. They are then placed in an apparatus similar to that used in Paris for roasting coffee, mixed with a small quantity of fine sand, and are turned round in it until, by the continued motion and the friction of the sand, the excess of gum lac has been removed, and they have received all the brilliancy of which they are susceptible.

Account of the Staffordshire Potteries, with a History of the Art.

Continued from page 65.

The clay being prepared, we will next consider some of the multifarious modes of operation by which it is converted into objects of use and ornament; and our first visit shall be to the THROWER, rather for the sake of preserving continuity in our remarks on the several processes, than in the hope of conveying new information to the reader; for there are few unacquainted with the wonder-working powers of "the potter's wheel." A ball of clay is placed on the centre of the revolving wheel, and by the simplest manipulation is made to spring at once into form and character, assuming at the operator's will any contour of which a circular vessel is capable, the plastic clay being formed or transformed with an ease almost incredible. Every "piece," when made, is cut off the wheel by a wire being passed under it.

When the *thrown* ware is sufficiently dry, it is transferred to the hands of the TURNER, whose business it is to finish it by forming the angles and curves more truly, and to impart a general smoothness and polish to the surface. This process resembles that of common wood-turning, but, from the nature of the material, is executed with greater ease and rapidity. The vessel is fitted upon a block, or chuck, attached to the lathe, and the turning is performed by means of thin iron tools—few in number and simple in form.

Articles that require handles are passed from the lathe to the workshop of the HANDLER. These useful adjuncts are made by pressure in moulds, made of gypsum, and, after being sufficiently dried, are fixed on the vessel with "slip." The adhesion is so immediate and perfect that in most cases the article may be lifted by the handle, without danger, before it has left the bench of the operator. When the handle is fitted the superfluous slip is removed with a sponge, and the parts of junction smoothed round with a small tool; the article is then finished, unless a spout or lip is required, as in the case of jugs and tea-pots. These are made and attached in the same manner as the handles.

Plates, dishes, saucers, &c.,—termed FLAT PRESSING—are made from moulds, which form the inside of the article, the exterior being given by "profiles" made of fired clay glazed. The clay is "batted" out to the required thickness and size, and laid upon the mould, which is placed upon a plaster block, having an iron axis and working upon

a pivot, the rotary motion of which is given sometimes by machinery, but more often by the workman's hand. The clay is worked to the mould by the application of wet sponges, and the profile being pressed on gives the desired outline. In this state the mould is carried to a chamber, immediately behind the workman, heated to a very high temperature,* and fitted round with shelves, where it remains till tolerably dry, when the profile is again passed over it, and the shrinking, consequent upon evaporation, having taken place, it is easily removed from the mould.

Soup-tureens, sauce-tureens, jugs, teapots, &c.,—termed HOLLOW WARE—are made from outside moulds, formed in two or more parts, according to the facilities which the shape affords for "drawing." The clay is prepared and batted out as in the "flat" pressing, and each part of the mould being separately lined with the clay, the parts are fitted together, and a strap passed round to secure them in their places: the whole is then worked compactly together from the inside, with sponge, particular attention being paid to connect firmly that part of the article where the mould is divided. When sufficiently dry, the mould is removed, and the seams on the article well rubbed down: the surface is also smoothed with a sponge.

The ware, being finished from the hand of the potter, is brought by him upon boards to the "GREENHOUSE," so called from its being the receptacle for ware in the "green," or unfired state. It is here gradually dried for the ovens; when ready, carried to the "SAGGER-HOUSE," in immediate connexion with the oven in which it is to be fired, and here it is placed in the "saggers." These are boxes made of a peculiar kind of clay, *(native clay,)* previously fired, not fusible at the heat required for the ware, and of forms suited to the articles they are to contain. A plate sagger will hold twenty plates,† placed one on the other. A little dry pounded flint is scattered between them if china, and sand if earthenware, to prevent adhesion. The purpose of the sagger is to protect the ware from the flame and smoke, and also for its security from breakage, as in the clay state it is exceedingly brittle, and requires great care in handling when dry, or what is called "white." The "setters" for china plates and dishes answer the same purpose as the saggers, and are made of the same clay. They take in one plate or dish each, and are "stood" in the oven in "bungs," one on the other.

The hovels within which the ovens are built form a very peculiar and striking feature in the appearance of the Pottery towns, and for-

* The following are the degrees of temperature in which the different branches work:—

Platemaker's hothouse,	108	degrees	Fahrenheit.
Dishmakers' "	106	"	"
Saucermakers' "	100	"	"
Throwers' "	98	"	"
Pressers' shop,	90	"	"
Printers' shop,	94	"	"

Those branches against which the temperature of the hothouse, is placed require that heat for drying their work and getting it off the moulds; the outer shops, in which they work the clay, may be from five to ten degrees less.

† This applies to earthenware plates. *China* plates are fired *separately*, in setters made of their respective forms.

cibly arrest the attention and excite the surprise of the stranger, resembling, as they closely do, a succession of gigantic beehives. They are constructed of brick, about forty feet diameter, and thirty-five high, with an aperture at the top for the escape of the smoke. The ovens are of a similar form, about twenty-two feet wide, and eighteen to twenty-one feet high, heated by fire-places or "mouths," (about nine in number,) built externally around them. Flues, in connexion with these, converge under the bottom of the oven to a central opening drawing the flames to this point, when they enter the oven, other flues termed "bags," also pass up the internal sides to the height of about four feet, thus conveying the flames to the upper parts. An aperture in the top allows the escape of smoke. When "setting in" the oven the firemen enter by an opening in the side, bringing the saggers with the ware placed as described; these are piled upon one another from bottom to top of the oven, care being taken to arrange them so that they may receive the heat, (which varies in different parts,) most suited to the articles they contain. This being continued till the oven is filled, the aperture is bricked up. The firing of earthenware bisque continues sixty hours, and of china forty-eight.* The ware is allowed to cool very gradually in the ovens for two days, when it is drawn in the state technically called "biscuit," or "bisque."

The ware when drawn from the oven is carried to the bisque warehouse, where it is examined, sorted, and put aside for further use. In this state it is ready for glazing, excepting when it is required for "printing," or a common style of painting, both of which processes are effected in the bisque. Of the painting it is only necessary to say that it is applied in this state merely for cheap decoration, but extremely coarse in comparison with the painting on the glaze termed enamelling.

There are two distinct methods of PRINTING in use: the bisque printing in general use, and the other on the glaze. The first is called "press-printing," and the latter "bat-printing." The pattern or subject is engraved upon copper-plates of different depths and degrees of finish, according to the style required. For the press it is engraved very deep, to enable it to hold a sufficiency of color to give a firm and full transfer on the ware. The printer's shop is furnished with a brick stove, having an iron plate upon the top, immediately over the fire, for the convenience of warming the color while being worked; a roller press and tubs of water. The printer has two female assistants, called "transferrers," and also a girl called a "cutter." The copper-plate is charged with color, mixed with thick boiled oil, by means of a knife and dabber, while held on the stove plate for the purpose of keeping the color fluid; and, the engraved portion being filled, the superfluous color is scraped off the copper with the knife; and it is further cleaned by being rubbed with a "boss," made of leather. (A thick firm oil is required to keep the different parts of the design from flowing into a mass or becoming confused when under the pressure of the rubber in transferring.) A sheet of paper of the necessary size and of a pe-

* The quantity of coals necessary for firing a bisque oven is from sixteen to twenty tons; for a "glost" oven, from four and a half to six tons.

culiar texture, called "pottery tissue," after being saturated with a solution of soap and water applied with a brush, is placed upon the copper-plate, and, being put under the action of the press, the paper is carefully drawn off again (the copper being placed on the stove,) bringing with it the color with which the plate was charged, constituting the pattern. This impression is given to the cutter, who cuts off the superfluous paper about it; and if the pattern consists of a border and centre, the border is cut away from the centre as being more convenient to fit to the ware separately. The impression is then laid by the transferrer upon the ware, is rubbed first with a small piece of soaped flannel to fix it, and afterwards with a rubber formed of rolled flannel. This rubber is applied to the impression very forcibly, the friction causing the color to adhere firmly to the bisque surface, by which it is partially imbibed. It is then passed to the other transferrer, who immerses it in a tub of water, and with a sponge washes the paper entirely away; the color, from its adhesion to the ware, and being mixed with oil, being unaffected by the water. It is now necessary, prior to glazing, to get rid of this oil, which is done by submitting the ware to a heat in what are called hardening-kilns, sufficient to destroy it, leaving the color pure. (This is a necessary process, as the glaze, being mixed with water, would be rejected by the print while the oil remained in the color.*)

Connected with this branch of the subject is "BAT-PRINTING," which is done upon the glaze. The engraving for this style is exceedingly fine; indeed, many plates we have seen are as highly wrought as book plates, and executed by the best engravers; not unfrequently engraved in London. No greater depth is required than for ordinary book engraving; indeed, very good impressions have been taken from some of the copper-plates engraved for the "Annuals." As the impression is not submitted to the heat necessary for that on the bisque, the medium of conveying it to the ware being also much purer, the copper-plate is first charged with linseed oil, and cleaned off by the hand, so that the engraved portion only retains it. A preparation of glue being run upon flat dishes, about a quarter of an inch thick, is cut to the size required for the subject, and is then pressed upon it, and being removed, draws on its surface the oil with which the engraving was filled. The glue is then pressed upon the ware, with the oiled impression next the glaze, and being again removed, the design remains, though, being in a pure oil, scarcely perceptible. Color, finely ground, is then dusted upon it with cotton wool, a sufficiency of which, adhering to the oil, leaves the impression perfect, and ready to be fired in the enamel kilns.

The materials comprised in the various GLAZES, for china and earthenware are—Cornish stone, flint, borax, white lead, glass, and whiting: these, having been ground together in proper proportions to the consistence of milk, form the glaze.† This process is effected in large build-

* A good printer is considered capable of taking off from twenty to twenty-five dozen plates per day.

† "The glaze is so composed as to be suited to the nature and quality of the ware to which it is intended to be applied—the preparation is effected by previously fusing together the different substances of which it is composed, so as to form viteous masses; these are afterwards broken up and ground very finely in a mill."

ings termed "dipping-houses," (china and earthenware being kept separate,) fitted up with tubs for the glaze, and stages for the reception of the ware when dipped, upon which it is dried and heated by a large iron stove called a "cockle," from which iron pipes, extending in various directions, convey the heat throughout the whole extent of the "houses." Each dipper is provided with a tub of glaze, in which he immerses the bisque ware. We may note the results of practice and experience in giving facility and dexterity of handling, so necessary to success in this process. The ware is held so that as small a portion as possible shall be covered by the fingers; it is then plunged in the glaze, which, by a dexterous jerk, not only covers the entire piece, but at the same time so disperses it that an equal and level portion is disposed over the whole surface, which, being porous, imbibes and retains it. The ware is handed to the dipper by a boy; another boy removes it when it is dipped. The glaze is opaque till fired, so that the design of printed patterns is completely hid after dipping till they have been submitted to the glost fire.*

The GLOST OVENS and process of FIRING are so similar to the descriptions given of the bisque firing that there is nothing worthy of remark except the difference of time in firing—china glost being fired 17 hours, and earthenware 15 hours. When drawn from the glost ovens the white ware is ready for the decorative branches of painting, gilding, enameling, &c., &c.,: the bulk of common printed ware, is, however, finished at this stage.

In describing the further processes of ENAMELING, we shall commence with "GROUND-LAYING," † as being the first in operation in all the designs in which it is introduced.

This branch is extremely simple, requiring, principally, delicacy and lightness of hand; the process is effected by a coat of oil adapted to the purpose, being laid upon the ware with a pencil, and afterwards leveled, or, as it is technically termed, "bossed," ‡ until the surface is perfectly uniform, as the deposit of more oil in one part than another would cause a proportionate increase of color to adhere, and consequently produce a variation of tint. This being done, the color, which is in a state of powder, is dusted on the oiled ground with cotton wool, to which it attaches itself, and the superfluity is cleared off by the same medium. If it be requisite to preserve a panel, ornament, or indeed any object, white upon the ground, an additional process is necessary, called "stenciling." The stencil (generally a mixture of rosepink and sugar and water,) is laid on in the form desired, so as entirely to protect the surface of the ware from the oil; it is then dried, and the process, as previously described, ensues. It is then dried in an oven, to harden the oil and color, and then immersed in water, which penetrates to the stencil, and, softening the sugar is then easily washed off, carrying with it any portion of color or oil that may be upon it, and leaving the ware perfectly clean. It is sometimes necessary,

* An able workman will dip about 700 dozen plates in a day.

† "The term given to the process by which the level surfaces of various colors so extensively introduced upon decorated porcelain is effected."

‡ The "boss" is made of soft leather.

where great depth of color is sought, to repeat these labors several times. The "ground layers" do generally, and should always, work with a bandage over the mouth, to avoid inhaling the color-dust, much of which is highly deleterious.

We now arrive at the more elaborate and costly processes of PAINTING and GILDING. The colors* used are mineral preparations, (worked in essential oils and turpentine;) and a very great disadvantage under which the artist labors is, that the tints upon the palette are, in most cases, quite different from those they assume when they have undergone the necessary heat, which not only brings out the real color, but also, by partially softening the glaze and the flux, causes the color to adhere to it. This disadvantage will be immediately apparent in the case where a peculiar delicacy of tint is required, as in flesh tones for instance. But the difficulty does not end here: for, as a peculiar and certain heat can alone give to a color its perfect hue, and as the color is continually varying with different stages of heat, another risk is incurred—that resulting from the liability of its receiving the heat in a greater or less degree, termed "over-fired," and "short-fired." We will cite rose color or crimson, which, when used, is a dirty violet or drab; during the process of firing it gradually varies with the increase of heat from a brown to a dull reddish hue, and from that progressively to its proper tint of rose; but if, by want of judgment or inattention in the fireman, the heat is allowed to increase beyond that point, the beauty and brilliancy of the color are destroyed, and it becomes a dull purple. On the other hand, should the fire be withdrawn too early, the color is presented in one of its intermediate changes, as already described. Nor must we forget to mention the liability to cracking and breaking in the kilns, by the heat being allowed either to increase too suddenly, or withdrawn suddenly; of course the larger and more costly articles are peculiarly hazardous. These vicissitudes render enamel painting in its higher branches a most unsatisfactory and disheartening study, and enhance the value of those productions that are really successful and meritorious.

The gold, being prepared for use, (in which state it is a black dust,) is mixed with oils similar to the vehicle used in painting, and is worked with the ordinary camel's hair pencil. It flows very freely, and is equally adapted for producing broad, massive bands and grounds, or the finest details of the most elaborate design. To prevent the necessity and expense of drawing the pattern upon every piece of a service where it is at all intricate, a "pounce" is used, and the outline dusted through with charcoal; this method also secures uniformity of size and shape. Women are precluded from working at this branch of the business, though, from its simplicity and lightness, so well adapted for them; the men resolutely opposing any attempts to in-

* The colors are metallic calces, incorporated with a very fusible flux; gold precipitated by tin, furnishes the crimson, rose, and purple; oxides of iron and chrome produce reds; the same oxides give black and brown, also obtained from manganese and cobalt; orange is from oxides of uraninm, chrome, antimony and iron; greens from oxides of chrome and copper, the former class being by far the finer; blues from oxides of cobalt and zinc; the fluxes are borax, flint, oxide of lead, &c.

fringe this "ancient regulation"—one that would be surely more honored in the breach than in the observance. Firing restores the gold to its proper color; which first assumes its character as "dead gold;" its brilliancy being the result of burnishing.

The ware being ready from the hands of the painters, gilders, &c., is carried to a receiving-room in connexion with the ENAMEL KILNS. The firemen select the ware from this room, according to the degree of heat it may require, and place it in that part of the kiln most likely to secure it. The different articles are ranged upon stages constructed of slabs or bats supported on props, all made of fired clay. The time of firing is from six to seven hours, according to the size of the kiln, and whether it contains any pieces of ware of unusual size and hazard, in which case the heat is brought forward very gradually. The "ground-laying" being executed with colors less fusible than those employed by the painters; the ware so decorated is fired in separate kilns, and at a greater degree of heat—a level, glossy surface being a great desideratum; and, as gold is often used as a decoration upon the "grounds," it would be liable to sink unless the under color had been capable of enduring a greater heat than is required by the gilding. The kilns are formed of large clay slabs made of a common clay expressly for this purpose; they are about 3 feet 6 inches wide, 4 feet 6 inches high, and 6 feet 6 inches long, with circular tops, and having flues beneath and around them: the fire-places, or mouths, are at the sides, and the flames passing through the flues encircle the kiln *externally*. Great care is taken to prevent the admission of smoke or flame into the body of the kiln, the fronts of which are enclosed by iron doors, having in them small holes, through which the firemen, during the firing, occasionally draw trials of color made upon small pieces of ware, and thus ascertain to a certain extent the progress of the heat. This, though a material assistance, still, being drawn from a particular part only, leaves a task requiring great care and nicety of judgment to manage successfully. Gold if not sufficiently fired will wipe off, and if overfired will not burnish.

The operation of BURNISHING is performed by females: the tools used for the purpose, called burnishers, are bloodstones, from hæmatite iron and agates, fitted into handles. The gold is first scoured with fine wetted sand, which tests the extent of the firing: if not sufficiently, the gold will not adhere, and therefore has to be repaired and passed through the kilns again; and if it be over-fired, the brilliancy will be destroyed, and it requires to be thoroughly regilt. After sanding, the burnishers are applied very briskly, and immediately produce a polish which is increased in brilliancy by repeated action. A cloth dipped in a solution of whiting is occasionally used to clean the surface.

The processes we may take next are those of MODELING and MOULDING.*

* The moulds in general are made of plaster of Paris, which, when properly prepared, has the property of absorbing water so effectually that the moisture is extracted from the clay, and the ware is enabled to leave the mould or "deliver" with ease and rapidity. Prior to use the plaster is put in long troughs, having a

Articles of an ornamental form requiring moulds first come under the province of the modeler. The design being made, the article is modeled in clay, allowance being made for the contraction which the clay, whether porcelain or earthenware, undergoes in the processes of drying and vitrification. And this feature, so peculiar to the business, involves a serious difficulty, and one that is often fatal in its results. For instance, the contraction of earthenware is one-tenth; of china, one-seventh, if pressed; and of earthenware, if cast, one-sixth; and china one-fourth.* The increase of contractility in casting arises from "slip" being used for that purpose instead of clay. In this state it is poured into the moulds, where it remains till a sufficient contraction has taken place to enable it to leave the mould, and also, as a consequence, that it may have acquired a sufficient firmness to support its weight when relieved from it. As the best method of illustration, let us suppose the object to be a figure or group of exquisite symmetry, in which any deviation in the outline or form is, in proportion to the extent to which it occurs, a blemish or a deformity. The figure or group we will assume to be two feet high in the model. The slip has been poured into the moulds of the various parts (sometimes as many as *fifty*) of the subject; the shrinking that occurs before they can be taken out is to the extent of *one inch and a half*, after which they are put together by the "figure-maker," the seams carefully removed, and the whole worked upon to produce the finish of the original model. The group is then dried thoroughly to be in a fit state for "firing;" and here again it suffers a further loss by evaporation of *one inch and a half*, and it is now consequently one foot nine inches. Again, in the "firing" in the bisque oven, its most severe ordeal, it is once more diminished to a greater extent, and is now altogether *six inches* less than the original, or *eighteen inches high*. Now, when it is borne in mind that this contraction should equally affect every part and portion of the object to produce a faultless whole, and also added to this the risks in the ovens of being "over-fired," by which it would be melted in a mass, and of being "short-fired," by which its surface would be imperfect, it must be admitted that very formidable difficulties present themselves; and considering that the finest and most elaborate specimens, whether of figures or ornaments, are the results of this process, it will cease to be a matter of wonder that so many objectionable forms occur, for, however good and pure the design and model may be, there is no protecting influence to save it from these casualties.

We may briefly indicate some particulars in which the Chinese and Japanese are still superior to their European rivals. Their transparent white glaze is generally below the European average, though

fire running underneath them—by which means the water is driven off, and it remains in a state of soft, fine powder; and if its own proportion of water be again added to it, it will immediately set into a firm, compact body, which is the case when it is mixed to form the mould.

Moulds of fired clay of a peculiarly absorbent texture are also in considerable use, and where they can be introduced are preferred for their increased durability.

* This is the average contraction. There may be a little variation in different manufactories.

specimens are occasionally seen superior to any of the Western productions. In their vitrifiable colors they have a very brilliant black not yet equalled, and a rich purple tinged with crimson which has never been approached in any of our imitations. Chaptal assigns copper as the basis of this color, but appears not to have been able to ascertain the proportions of the composition. The deep green on the Japanese specimens brought to England by way of Java, two of which we have been permitted to examine by the gentleman to whom they belong, are superior to any similar colors produced either in China or Europe; but China again has a superiority in olive-green and in a rich orange, of which some magnificent specimens were to be seen a few years ago in the windows of a shop in Hanway-street.

Lond. Art-Union.

Extract from the Third Report upon the Action of Air and Water, whether fresh or salt, clear or foul, and of various Temperatures, upon Cast Iron, Wrought Iron, and Steel. By* ROBERT MALLET, Mem. Inst. C. E., M. R. I. A.

Conclusions drawn, from discussing the results given in the tables, as regards Iron Ships.

The durability of iron ships has become one of the most important questions involved in the present inquiry, from the rapid extension which this novel branch of naval architecture has received, and is still receiving. Amongst other considerations as to their fitness for distant voyages, and their economic adoption, is that of their durability in respect to corrosion as compared with timber-built vessels, their relative liability to "fouling," and what are the means we possess of preventing or retarding both. If the former, viz: the durability, be ensured, the vessel's remaining clean under water is nearly, if not wholly, attained, for both marine animals and plants adhere with obstinacy to the oxidized iron of a rusty ship's bottom, on which they thrive and multiply, while to clean iron they will scarcely attach themselves.

From the importance of this subject I have been induced to give it a very particular consideration, and propose here to enter somewhat fully into the principal agents of corrosion of iron ships, the directions in which these are found, or may be expected, to act most destructively; to describe the peculiar methods which I have been led to devise for preventing corrosion, also those for preventing the "fouling," which is admitted by the most sanguine advocates of iron ship-building to be at present the salient evil of the system. This matter has acquired increased importance from the recent discovery of Professor Daniell of the existence of sulphuretted hydrogen in the sea water of

* Made to the 13th meeting of the British Association for the advancement of Science.

the tropics, which, our previous experiments show, acts most destructively on iron, as well as on the copper sheathing of timber vessels.

The lower part of an iron ship's floor is exposed to putrid bilge-water(if permitted to accumulate;) this, on grounds already stated, is an agent of great corrosive power, and when heated, as beneath the boilers in steam-vessels, its effects are greatly increased, as far as action from the inside is concerned; therefore the floor and futtocks may be expected soonest to require restoration. This, I am informed, is actually the case in those thin sheet-iron "fly-boats" used for passengers in Scotland and Ireland on the canals.

A remedy for this suggests itself which it would be highly desirable to make trial of, which could be of no inconvenience, and if successful, would have the additional advantage of destroying all smell of bilge-water in a vessel and of preserving her floor at all times sweet.

It has been before remarked that a small quantity of an alkali in solution, even in salt water, is capable of arresting oxidation of iron; it is highly probable that an alkaline earth-lime, for instance, in solution possesses the same power, indeed, Payen's experiments make this certain; there would be no difficulty in keeping lime-water in the place of bilge-water over the floor of an iron ship, to any desirable degree of saturation. The ship's well being periodically pumped out dry, fresh water let in, and a few lumps of dry lime dispersed, a fresh supply of lime-water would be kept up, which would not only preserve the bottom, but destroy the putridity of the bilge-water, of which some will be found even in the stanchest vessel. No injury would be likely to result to the few timbers which would be exposed to its contact.

Exteriorly, the action of air and water will be greatest just between wind and water, and abreast of the paddle-wheels in steamers, where the constant splash from the paddles strikes, and wherever the shell of the vessel is heated by the contact or proximity of the boilers, &c.; but the difference in other parts of the hull is not likely to be considerable unless in very fast-going vessels.

It has long been an opinion amongst those concerned in iron shipbuilding, that "an iron vessel, when kept in constant use, is not only free from oxidation, but presents no more appearance of corrosion than railway-bars, which (say the advocates of this doctrine) are well known to remain uncorroded so long as the carriages continue to roll over them." "If the iron ship be kept in constant use, *i. e.*, in constant motion through the water, there is no appearance of deterioration; but lay her up for a few months, and the usual appearances of atmospheric action become visible, accompanied by a rapid corrosion of the points exposed." With respect to this singular opinion as to railway bars, we shall have more to say presently; what analogy subsists, however, between a railway bar and an iron ship it is hard to see. I do not doubt the fact that an iron ship kept constantly in motion through the water will present much less *signs* of corrosion than she will do if laid up for an equal time, but the fact does not

warrant the conclusion; on the contrary, this fact rightly interpreted is the surest possible proof, and that too from the testimony of those most advantageously circumstanced for judging, that rapid corrosion does take place.

It has been heretofore shown, that when iron oxidates in sea water, the rust, when first formed, is soft and pulverulent; it has also been shown that every metal, iron included, is electro-positive to its own oxides; in other words, that the peroxide of iron formed, acts as an acid towards the iron upon which it lies, in the same way exalting the rate of corrosion as the plumbago formed on cast iron has been shown by the present set of experiments to do upon it.

Now it is admitted than an iron ship at rest does corrode: if so, peroxide of iron is formed if the ship continue long at rest. This coat of oxide gets harder and forms a scale of oxide, which yet more promotes the rate of corrosion; but if the ship be kept in motion, the oxide formed, soft and pulverulent at first, is *swept off* by the passage of her sides through the water nearly as fast as it is formed, and hence, while corrosion is still going on, the exposed surface of iron, when examined, presents a clean and *apparently* uncorroded appearance.

Thus it is not true that an iron ship constantly in motion is incorrodible by sea water; on the contrary, corrosion does go on, and just at whatever rate the conditions of exposure warrant, in a surface of iron whose oxide is removed nearly as fast as it is formed, that is to say, which is exposed only to the corroding effects of the salt or other water, &c., and not to this together with the effect of its own peroxide; but it also follows, from the explanation above given of the phenomena, that the real rate of corrosion of an iron ship is less, and probably a good deal less, while she is kept in motion than while she may be at rest; and for the same reasons her tendency to "foul" is less while in motion than at rest.

By others it has been fancied that magnetism in some occult way interfered with corrosion in iron ships. There is no doubt that every iron ship becomes a magnet by induction from the earth, but the intensity will depend upon the ship's bearing, at any moment, as well as upon other obvious conditions. Admitting, however, that an iron ship were at all times a permanent magnet, no known fact warrants the supposition that its rate of corrosion would be in the slightest degree altered thereby.

The experiments cited by Levol, as apparently leading to a different conclusion, I have since found do not sustain the view of that author. The deficiency in rate of precipitation, &c., observed by him, arose from mechanical impediments introduced by the evolution of gas bubbles, and affected by the different position of his wires in the solution; and had nothing to do with their magnetism.

I therefore look upon it as perfectly certain that iron vessels corrode just as any other mass of iron in similar conditions will. I would add, that no *mere inspection* of surface is sufficient to determine in this case whether oxidation has taken place or to what extent, nor can any sufficiently precise determination of amount of corrosion be obtained

by drilling holes through the plates and *measuring* their thickness. This method might give some answer after a quarter of a century's corrosion; but for any moderate period no correct data as to the loss of metal can be had, but by a plate of large size *and known weight*, attached to the ship's hull by rivets or screw-bolts, detached after exposure and *again weighed;* and this experiment has not to my knowledge ever yet been made.

As the hulls of iron ships cannot be ordinarily got at to keep them uniformly covered with any common paint or varnish (which have however alone but a limited palliative effect in preventing corrosion,) such vessels should in all respects be viewed with reference to corrosion, as if the iron was always quite bare; and if so, Table XV., before given, affords data for determining their duration if *wholly unprotected*, but, as we shall see hereafter, iron vessels may be so treated, that in regard to corrosion it is difficult to assign a limit to their durability, which it is generally admitted depends simply on the question of corrosion.

The plates of an iron ship are likely in general to be corroded most round the rivet-heads, both outside and inside, and adjacent to any spots where the plates have been *hardened* by hammering or bending, or in any other way have had their homogeneity destroyed, and least round the bows, &c., where the oxide formed is swept off by the ship's motion through the water.

The contact of oak timber especially, and generally of all timbers which contain tannic or gallic acids, is extremely injurious to iron, and for keelsons, &c., or other timbers in contact with iron and water, teak should always be used in preference, which does not act at all, or but very slightly, upon iron. The bolts and nails of a gate of the fort at Canara, East Indies, after having been exposed to the weather for half a century, were found as sound as when put in: the gate was of teak. In the "Chiffone" frigate certain teak planks had been bolted to her sides; on subsequent removal, the iron was sound and uncorroded in the teak, but eaten through in the oak.

This injurious effect of oak timber as applied to iron ship-building, might however probably be completely obviated by steeping the timber, prior to insertion, in a solution of sulphate of iron, which would engage the whole of the organic acids which act so injuriously upon iron. The oak would become black from the gallate and tannate of iron formed in its pores; its durability would most probably be increased fully as much as by steeping in sulphate of copper, for which, as a mode of preventing dry-rot, a patent has been obtained, and there is no reason to suppose that the timber would suffer any deterioration in toughness, while it would certainly become harder.

Kyanized timber of all sorts is destructive to iron in sea water to a prodigious extent; a portion of the corrosive sublimate (whether more or less changed) contained in the pores of the wood, is decomposed by the contact of the iron, and the quicksilver reduced to the metallic state, which, by its powerful electro-negative relation to iron, promotes the corrosion of the latter. The actual amount of corrosion on best

Staffordshire iron, by my experiments, when in sea water and in contact with kyanized oak, amounted in two years to a depth of 0·122 of an inch of iron removed all over the surface, while the same iron freely exposed to the sea water alone, lost not half so much in the same time. Indeed the utility of kyanizing timber which is to be immersed in sea water appears very dubious, even if it were in this respect harmless; for M. Lassaigne has shown that whatever be the nature of the combination which the corrosive sublimate forms with the albumen of the wood, it is soon washed out, being soluble in salt water; and I have already stated that, in timber freely exposed in sea water, kyanizing is no protection against marine boring animals, kyanized oak being eaten through, two inches thick, in about two years, by the *Limnoria terebrans*, in Kingstown Harbor.

Of course the contact of a metal electro-negative to iron, as lead or copper, with iron ships, either exteriorly or interiorly, should be avoided, and when it is inevitable, increased scantling should be given to the plates, &c., at and around the spot.

The contact also of brass should as much as possible be avoided; but the injurious effects of brass depend much upon the relative proportions of its constituent metals, and by a proper choice in this respect may be made very small. Brass or the alloys of copper and zinc, are to be preferred to gun-metal or those of copper and tin, *all* of which greatly promote the corrosion of iron when in contact with them in a menstruum.

It is a good palliative when copper or brass ***must*** be in contact with the iron, as in the flanches of sea-cocks, &c. in steam vessels, to interpose a thickness of patent felt, saturated in boiled coal-tar or in wax, or other non-conducting substance; no interposition of "short iron pipes," or other metallic matters, unless masses of zinc, will be of any use; and the effect of local corrosion, thus produced, especially about the engine-room and boilers in iron steamers, demands the most scrupulous caution, much more than appears yet to have been given it, gun-metal sea-cocks, copper blow-off pipes, &c., being at present in general attached directly to the iron hull, which are certain soon to cause the iron plate round them to be eaten away, and thus the vessel is rendered leaky in a vital point and probably at an unexpected moment. The application of a thick zinc flanch outside the ship's side or bottom, at the junction of such a cock or pipe, would be a remedy, but would promote fouling; increased local scantling, and non-conducting flanches between the electro-negative metal and the iron, are most to be commended.

There are several substances found in commerce, the contact of which with the iron of ships, when carried as loose cargo, is more or less injurious, and unless an effective method of protection be adopted, such articles should not be taken in iron vessels but at commensurate freights; some of these may be named, as pyritose wet coal, sulphur, sulphur stone, gypsum, galena, copper ore, or other metallic sulphurets, when wet; alum, salt, bleaching salts; acids of all sorts, when not rendered secure against escape; wet bark for tanning, or other matters containing gallic or tannic acids, &c.

The following extract from our Tables gives the relative values of several of the principal sorts of wrought iron and steel found in commerce, in respect to durability in clear sea water; their relative rates of corrosion are *directly* as the numbers attached to each, and hence the values of the several sorts of iron, &c. for ship-building are *inversely* as those numbers.

Make of Iron.	Inverse Relative Value.
Common Shropshire bar,	36·14
Tilted cast iron,	13·38
Cold short bar, Staffordshire,	13·27
Shear steel, soft,	12·28
Best bar iron, Bradley,	12·05
Spring steel, tempered,	11·81
Blister steel, soft,	11·72
Best bars and plates, Doulais, (hot blast)	10·83
Swedish iron, Dannemora,	10·82
Red short bar, Staffordshire,	10·78
Common plates, Banks,	10·60
Common Shropshire bar, case hardened,	10·14
Best plates and bars, Forest of Dean,	10·08
Cast steel, as hard as possible,	9·38
Best bars and plates, Doulais, (cold blast)	8·85
Low Moor plates,	8·55
Best faggotted scrap iron,	2·52

From the foregoing table, it is obvious that plates rolled from scrapped iron would be the most durable for ship-building; the Low Moor comes next to these; and to these again, the plates from South Wales.

I now proceed to make some observations upon one or two of the methods of protection for iron which have been recently published, before giving the details of that which I have proposed.

The whole of the various methods that have been from time to time proposed for protecting iron from corrosion, may be divided into two classes: those which protect the iron by a mechanical covering, more or less perfect, and itself not acted on by the corroding agent; and those wherein, by the contact of some other body, a change is produced in the electric or chemico-polar condition of the iron with respect to the corroding agents, such that they cease to be so with reference to it.

To the first class belongs the whole tribe of paints and varnishes, and every attempt to cover or *sheathe* the surface of the iron with another metal which is electro-negative to it. The principal methods of this class which have been recently patented, are those of Miles Berry (a communication), for coating iron with alloys of zinc and copper by cementation (May 1838, Newton's Journal, conj. series, vol. xv. p. 91); Neilson's (of Glasgow), for coating iron with brass, by dusting the interior of the mould with brass filings before the metal is poured in &c., a process absolutely useless; and Joseph Shore's, sealed March

1840 (Rep. Arts, No. 84, December 1840), for precipitating copper or nickel on iron by Spencer's electrotype process; and Elkington and Ruolz's process, already spoken of, patented in December 1840, which includes both classes of protection.

To this class also Wall's (of Bermondsey) process, so much brought before the public, may be said to belong, inasmuch as (although, with reference to zinc or copper, this process may produce a change in the chemical relations of those metals to air and water) it has no such effect upon iron, and merely acts upon it as an imperfect but most expensive paint or varnish.

The principle of the second class has been already fully pointed out in preceding Reports, and its conditions experimented on and stated. It has been stated that Sir H. Davy, Edmund Davy, Pepys, and Sorel, long since invented or applied this sort of protection to iron.

The principal inventions dependent upon this method which have been patented, are those by H. W. Crauford (sealed April 1837, Rep. Arts, N. S. vol. ix, p. 289), and Fountainmoreau's (sealed May 1838, Newton's Journal, conj. series, vol. xvi. p. 289). These two patents are in fact one; they are essentially the same, differing only in certain details of application, &c. They both consist in the application of a thin coating of zinc to the whole surface of the iron, by dipping the iron into fluid zinc, when properly cleaned beforehand, or by coating it with a paint, or rubbing it, or lapping it up in a powder of metallic zinc.

Of these various methods not one is completely effective, the causes of which have been already fully discussed throughout these Reports.

The paint made of powdered zinc, and Wall's mercurial paint have no efficacy of an electro-chemical kind whatever towards iron. They differ in no respect from any other paint in being towards *it* mere mechanical coverings, more or less perfect. The result of experiments on the zinc paint have been already given. Wall's patent, which describes an absurd and roundabout process that reminds one of the recipes of the alchymists, and can scarcely be the result of chemical knowledge is, when stripped of its useless encumbrances, simply a mode of making a mixture of several salts of iron and mercury, chiefly sesquichloride and sesquioxide of iron, and subchloride and subnitrate of mercury, with probably suboxide of mercury, which being obtained, the whole is ground into a thin "bodyless" paint with linseed oil; when the paint is long exposed to sea water in contact with zinc or copper, it is *possible* that a small quantity of the mercury may be reduced to the metallic state, and may amalgamate the surface of a *zinc* or *copper* plate in contact with it; but it cannot, under any conceivable circumstances, have the smallest protective power over iron, beyond that which the linseed oil alone gives, the greasy coating of which probably enabled the patentee's prepared plates to resist the acids, &c., applied by those whose testimonials to that effect have been published. In some specimens of zinc and iron which I received prepared according to this process, I found there was not the slightest

protection from corrosion when once the greasy film of oil was removed.

I now pass to the second class of methods of protection. Zinc is the only known metal that can be practically used as an electro-chemical protector to iron; it can be applied, in a massive form, locally or at particular centres of action, or it can be diffused in a thin coat of zincing over the whole surface.

There is no considerable difficulty in the first mode of application in most cases, but it is, after the lapse of a greater or less time (generally only a few weeks), nearly useless, from one or both of two causes. Zinc is so slightly electro-positive to iron, that its protective power is nearly destroyed whenever a few spots of red rust have formed anywhere upon the iron it is in contact with; the peroxide acting as an acid towards its own base in both fresh and sea water, the surface of the zinc gets covered in the latter with a hard crystaline coat of hydrated oxide of zinc and of calc-spar, which retards or prevents its further corrosion, and thus permits the iron to corrode. The details of these reactions have been given at length in preceding Reports.

These phenomena also occur when the surface of the iron is all zinced over; but the insurmountable objection to zinced iron is, that in about two years nearly the whole of the thin coat of zinc is oxidized and removed even in fresh water, and in less time in sea water; further, the tendency of zinc to oxidate when fluid and at a high temperature, say 700° Fahr., is so great, and the methods of cleaning the surfaces of iron to be zinced heretofore practised so imperfect, that the surface of iron is never perfectly covered; and whenever an uncovered spot occurs and is exposed to air and water, after a time red oxide is formed, with the results above stated. Zinc, alone or unalloyed, at its fusing temperature, in process of working, gets its oxide mixed up with the metal, which adheres in minute patches to the iron, every one of which becomes the centre of subsequent oxidation.

I will not attempt here to enter upon the theoretical consideration of the process about to be described, but confine myself to a description of the methods to be pursued and the results obtained. These methods of preventing the corrosion of iron, whether cast or wrought, or of steel, are applicable to articles formed of these metals of whatever sort; and the methods of preventing the "fouling" of iron vessels, or vessels sheathed with iron, are appplicable to all articles of these metals immersed in sea or fresh water; I therefore propose their application to all manner of articles of cast iron, wrought iron, or steel; but as by far their most important and valuable application is to the protection of ships built of iron, I will confine my description to the methods of applying my process to such only, from which may be readily understood how it is to be applied to all other articles of iron, &c.

By the word "fouling" as applied to ships, iron buoys, floating beacons, &c., is meant the attachment and adherence to their surfaces, when immersed in sea or certain fresh waters, of various marine or fresh water animals of the molluscous and testaceous classes, and of aquatic plants.

The method of preventing corrosion and "fouling" of iron

vessels consists of three principal operations; the first of which is designed to prevent corrosion, the second aids the former, and also prevents the first part of the process being afterwards interfered with by the third operation, which has reference solely to the prevention of "fouling." Hence, for all other articles of iron, except certain of those immersed in sea or fresh water, the first two operations are alone requisite, and in some cases the first only. I proceed to describe in detail the modes of performing the several operations.

The first consists in covering the iron with a particular alloy of zinc in fusion; for this purpose the iron surfaces require to be previously cleansed from adhering oxide. The boiler-plates, angle-iron, &c., to be used for ship building should not be permitted to acquire any red rust previous to the operations about to be described; and if required to lay by for a considerable time previous to use, or to be transported to a distance, should be rubbed over with drying oil or other greasy matter to preserve them temporarily from rust; this oily coating may be afterwards removed by immersion in any alkaline ley.

The plates or other pieces of cast or wrought iron or steel are to be immersed on edge (or in such a position that the detached scale of oxide can readily fall off), in a suitable vessel of wood, pottery, stone, or lead, containing dilute sulphuric acid (specific gravity about 1·30,) or dilute hydrochloric acid, specific gravity about 1·06 at 60°, formed by diluting these acids respectively, as they are usually found in commerce, with rather more than an equal bulk of water.

The diluted acid is best warmed, which may be conveniently done by a steam jacket round the vessel, or by blowing steam into the acid, as it is desirable that the scale of oxide should be detached as rapidly as possible from the surface of the iron. The acid vessel, in operating on the great scale, is best formed so that the lower portion of acid and the scales which have deposited can be occasionally withdrawn, to prevent waste of acid or increased length of time in the cleansing process. The iron must be *wholly immersed*, and the bubbles of gas formed on its surface must be free to ascend in the fluid and escape.

As soon as the scale of oxide has become detached or loosened from the iron, the plates or other pieces are to be removed from the "cleansing bath" and washed with cold water. The surfaces are now to be thoroughly scoured by hand or by power, with sand, or emery, or with pieces of grit stone, while exposed to a small running stream of water, until they appear quite clean, bright, and metallic.

The plates or other articles of iron are now immediately, and without being permitted to dry, immersed in the "preparing bath," in which they are to lie until about to be covered with the alloy of zinc to be hereafter described. The fluid which forms what may be called the "preparing bath" is made in the following way:—To a saturated cold solution of chloride of zinc is to be added an equal bulk of a saturated cold solution of sal-ammoniac, and to the mixed solutions as much more sal-ammoniac in the solid state is to be added as they will dissolve; or these solutions may be made and mixed hot, and the solid sal-ammoniac then added, if thought more desirable, but the addition of more water on cooling is then requisite. The "preparing bath" may

also be formed of sulphate of zinc and sulphate of ammonia, or acetate of zinc and acetate of ammonia, or of any other soluble double salt of zinc and ammonia, or salt of manganese and ammonia; the nitrates of zinc and ammonia are the least advantageous, but none answer the purpose so well as the above-described chloride of zinc and sal-ammoniac. No free acid should be present in these solutions.

The iron cleansed by the previous operations, is immersed in this solution, contained in vessels of wood, or pottery, or stone, at common temperatures; as soon as the surfaces of the cleansed iron appear covered all over with minute bubbles of gas, it is in a fit state to be submitted to the final operation of immersing in the metallic alloy with which it is to be coated; but the iron, when once cleansed, may be permitted to remain in the "preparing bath" for any moderate length of time, without injury to the subsequent process. The "preparing bath" becomes therefore a convenient receptacle for depositing and preserving the cleaned or polished iron in until ready for coating with the alloy.

(To be continued.)

Notes on the Hydraulic Ram.

The invention of this singular engine is due entirely to the genius of the celebrated Montgolfier, who made it known in 1797; the peculiar simplicity of its construction, as well as of its mode of action, attracted the attention of hydraulic engineers, and of mathematicians, and in 1804, Eytelwein conducted a series of experiments upon a well digested plan, to develop the power, the proportions, and other relations requisite to its greatest efficiency. The oscillatory motion of the water in the ram, and the alternate action of the valves, indicate the physical causes which produce the effect of this machine; they are nevertheless still very far from being sufficiently understood to furnish the basis of a mathematical theory. The passive resistances, and especially those arising from the shock or blow given by the valves, interpose difficulties in affixing their value, which render any estimate of the *whole dynamic effect* almost impossible. Experiment alone can instruct us as to the *useful* effect it is capable of affording.

D'Aubuisson de Voisins has given a succinct account of the researches of Montgolfier and of Eytelwein, and these notes are chiefly derived from it.

The parts of a ram are, a pipe connecting a reservoir of water with a case or chest, containing two valves—an air chamber, and a rising or supply pipe. The pipe attached to the reservoir was, by Montgolfier, termed the body of the ram, and the valve chest its head. Further description of the construction of the machine and of its mode of action is unnecessary here, as it may be readily found in every modern work on hydraulics.

The largest ram ever erected was put up at Mello, near Clermont sur Oise, by the inventor's son. Its principal dimensions were:

Length of body pipe,	108 feet.
Diameter of ditto,	4·3 inches.
Weight of ditto,	3190 lbs.
Weight of head,	440 lbs.
Contents of air chamber,	1½ gallons.

The tail or stop valve consisted of a horizontal metal plate pierced with seven holes, each covered by a hollow ball 1½ inch diameter; it beats 60 strokes per minute. This ram worked under a head of water of 37 feet, discharging 31½ gallons per minute, and raising 3·85 gallons to a height of 195 feet. The ratio of the useful effect to the laboring force expended was ·653. The comparison of effect is made without taking into account the *velocity* of the motion; it is the weight of water raised to a certain height in a determinate time. Calling p'' this weight, and H″ this height, the effect is p'' H″.

The corresponding force (P being the weight of fluid furnished by the stream in the same time, and H the height of the fall or head of water,) is expressed by P H.—The ratio of these is consequently $\frac{p''\ H''}{P\ H}$, or since $p'' : P :: q : Q$, the ratio is $\frac{q\ H''}{Q\ H.}$

The following table shows the ratio and the effect of ordinary rams. The first experiment was made upon the ram constructed by Montgolfier himself, at his house at Paris; the second, upon that erected by his son, above cited; and the others, upon rams in the neighborhood of Paris, mentioned in the Traité des Machines, p. 161.

	Height.		Water per minute.		$\frac{q\ H''}{Q\ H}$	
	Fall. H.	Elevation. H.″	Expenditure. Q.	Delivered q.		
1	8′·6″	52′·8	15	1·37	·57	
2	37·2	195·0	31	3·85	·653	Mean ratio
3	34·9	111·11	18½	3·74	·651	$q\ H'' : Q\ H = ·65$
4	3·3	14·11	4·37	59·18	·629	
5	22·10	196·10	2·86	0·22	·671	
	Ft. In.	Ft. In.	Gallons.	Gallons.		

Eytelwein made, at Berlin, 1123 experiments, gradually and successively varying the dimensions of the several parts of the hydraulic ram. He confirmed the effect produced in each case, and deduced rules for the dimensions and arrangement of the parts, suitable to the greatest effect.

The following table contains some of the experiments upon the largest of the rams he employed, in its most advantageous arrangement, viz:—

Length of body pipe,	43 feet 9 inches.
Diameter of ditto,	0 2¼ "
Capacity of air chamber,	1·94 gallons.
Area of opening of tail or escape valve,	3·74 square inches.
This area in the first experiment was raised to	6·2 square inches.

The valves were clack valves, and the escape valve was placed be-

tween the air chamber and the reservoir. These experiments may have their result expressed by the following formula,

$$\frac{q\ H''}{Q\ H} = 1{\cdot}42 - {\cdot}28\sqrt{\frac{H''}{H}}$$

But as this has been deduced from experiments which in some measure refer to the maximum effect of which the water ram is capable, we may obtain the ordinary results exact enough by reducing the numerical coefficient about $\frac{1}{6}$, and we get

$$p\ H'' = 1{\cdot}2\ P\ (H - {\cdot}2\sqrt{H\ H''}.)$$

See D'Aubuisson p. 503,—also Taffe, Application de la Mechanique, p. 278.

No. of Strokes per minute.	Height in feet of		Ratio.	Gallons of water per minute.		Ratio $\frac{q\ H''}{Q\ H}$.		Ratio. $\frac{Q}{q}$.
	Fall. H.	Elevation. H''.	$\frac{H''}{H}$.	Expended. Q.	Raised. q.	Experiment.	Formula.	
	′ ″	′ ″						
66	10 0	26 4	2·63	10·65	3·39	0·9	0·97	2·92
54	10 2	32 4	3·18	13·97	3·83	0·873	0·92	3·67
50	9 11	38 8	3·9	12·01	2·622	0·85	0·87	4·58
52	8 0	32 4	4·	8·16	1·687	0·847	0·85	4·72
45	8 9	38 8	4·4	10·85	2·09	0·845	0·84	5·2
42	7 5	38 8	5·21	9·92	1·5	0·787	0·78	6·62
36	6 0	38 8	6·5	8·89	1·05	0·754	0·71	8·62
26	4 6½	32 4	7·2	5·23	0·495	0·672	0·67	10·7
31	5 0	38 7	7·7	8·05	0·704	0·667	0·65	11·54
23	4 1	38 8	9·47	11·11	0·649	0·548	0·56	17·2
17	3 0	32 2	10·7	10·8	0·479	0·473	0·51	22·6
15	3 3	38 8	11·9	12·34	0·363	0·352	0·45	33·8
14	2 6	38 8	15·5	11·95	0·22	0·284	0·32	54·6
10	1 11½	38 8	19·3	9·81	0·088	0·181	0·18	106·6

According to Eytelwein, the length of the body pipe ought *not* to be *less* than $\frac{3}{4}$ of the height to which the water is to be raised. Its diameter in inches, (when Q″ is the number of gallons *expended* per *second*) $= 4\frac{1}{2}\sqrt{Q''}$. The diameter of the rising or delivery pipe should be one-half of this. The air chamber should be as large as the cube content of the rising pipe. The two valves should be close to each other, but it is of little moment whether the escape valve is above or below the air chamber, with regard to the stream of water. The opening of the escape or tail valve should not be less than the section of the body of the ram.

Example.—Let it be required to raise 220 gallons of water per hour to a height of 46 feet; the disposable head of water being 4 feet; to determine the expenditure of water per second, and the principal dimensions of the ram—

220 gallons per hour = 2200 lbs. = 36·6 lbs. per minute;

$$36{\cdot}6 \times 46 = 1{\cdot}2\ P\ (4 - {\cdot}2\sqrt{46 \times 4.})$$

$$\text{or } P = \frac{36{\cdot}6 \times 46}{1{\cdot}2\ (4 - {\cdot}2\sqrt{184})} = \frac{1403}{1{\cdot}29} = 1087{\cdot}6 \text{ lbs. per minute;}$$

and 108 76 gallons per minute = 1·81 gallons per second.

Diameter of body pipe = $4\frac{1}{2}\sqrt{1{\cdot}81} = 4\frac{1}{2} \times 1{\cdot}346 = 6$ inches, nearly.

Length of ditto should not be less than 44 feet,—say 50 feet.

Diameter of rising pipe = $\frac{6}{2} = 3$ inches.

Content of ditto = $\frac{3^2 \times {\cdot}7854 \times 46}{144} = 2\frac{1}{4}$ cube feet = capacity of air chamber.

Diameter of opening for escape valve = 6 inches.

If ball valves are used, their weight should be twice that of the corresponding bulk of water.

D'Aubuisson, p. 504, makes the following important remarks:—"The hydraulic ram has only been employed hitherto, in raising small quantities of water, and, therefore, in producing small effects. The greatest effect obtained by Eytelwein from 1123 experiments was only 1476 lbs., raised one foot in a minute; and the greatest from the rams used in France is but 7500 to 8500 lbs., raised one foot in a minute, or about one half the work done by a horse, harnessed in a gin."

It is very doubtful whether the ram can be used for raising large volumes of water. The violent shock of the valves, and the heavy pulsations of the machine, derange the frame and the foundations made to support it. This it has been attempted to obviate by materially increasing the weight of the ram, and in this way the loss of effect arising from the movement of the machine may be diminished, and the evil remedied up to a certain point.

The strong frame-work and heavy masonry constructed to support large rams, have been entirely destroyed after a certain length of time; and it is much to be feared, that the employment of this engine, in other respects so remarkable, will continue to be restricted, and that its sphere of usefulness will not extend beyond the supply of water to an isolated house or manufactory.

1, *Lancaster-place, Nov.* 5, 1846. J. H.

Civil Eng. and Arch. Journal.

Self-Registering Instruments.

Mr. Brooke stated that he had applied to the barometer, thermometer, and psychrometer, a new apparatus, by which also he had obtained a register of variations of the declination magnet, a description of which he had transmitted to the Royal Society. This may be briefly explained to consist of two concentric glass cylinders, which enclose between them a piece of photographic paper, and are carried round by clockwork once in twelve hours. These are covered by a blackened case having a narrow slit parallel to the axis of the cylinders,

through which a small point of light, reflected from a spherical concave mirror attached to the magnet, and then refracted through a cylindrical lens, passes and impresses the paper. Some photographs were exhibited, and were much approved of by the President, by Dr. Whewell, and other leading members of the committee who were present: from these the position of the magnet at any given time might generally be determined within ten seconds, and frequently within five. The self-registering barometer was described as a syphon barometer, the extremities of which were nearly an inch in diameter, and exactly the same size, being adjacent portions of the same tube. A glass bulb having a tubular stem rests on the surface of the mercury in the lower end of the tube, and is maintained in a vertical position by small friction-rollers. On this stem rests the short arm of a balanced lever, and the barometer is so placed that the long arm of the lever carries a black paper screen between a lamp and the slit in the apparatus above described; the light of the lamp being condensed by a cylindrical lens placed in front of and paralled to the slit in the apparatus. This screen has a narrow slit in it, at right angles to the former; and the small portion of light, transmitted through the point at which the two slits cross each other, produces a trace upon the photographic paper. The ratio of the arms of the lever may be determined at pleasure, so as to magnify the variations from two to ten times; and as the line is very sharply defined, when magnified five times, the variations may be readily determined to the thousandth part of an inch. The author stated that he had not had the opportunity of determining the errors of the instrument, arising from friction and other causes, but he believed them to be very small. In the self-registering thermometer and psychrometer the mercury in a wide flat bore of the tube, intercepts a portion of the focal line of light formed by refraction through a cylindrical lens placed as above. This does not require more particular description, as it differs only in details from similar apparatus, of which a description is in print.

Mr. F. Ronalds, on presenting his third annual volume of observations and experiments made at the Kew Observatory, described his experiments on the photographic self-registration of the electrometer, the barometer, the thermometer, and the declination magnetometer, explained his existing apparatus for these purposes, and exhibited the resulting photographs—but first briefly adverted to his previous proposals in 1840 and 1841, and experiments in 1844, relative to the subject. The principal characteristic of his improved system is a peculiar adaptation of the lucernal microscope. An instrument of this kind was employed in July 1845 to register the variations of Volta's atmospheric electrometer. The pair of straws were properly insulated and suspended within the body of the microscope, and towards its object end. A condensing lens was placed at the end itself, and a good lamp stood beyond it; a strong light was therefore projected upon those sides of the straws which were turned towards the condensing lens, and the other sides were in deep shade. The light also impinged upon a little screen fitted into the back of a case about two feet long fixed to the eye end of the microscope, at right angles with it, and vertically; through this

screen was cut a very narrow curved slit, whose chord was horizontal, and radius equal to the length of the straws. Between the electrometer and the screen an excellent combination of schrometer lenses by Ross was accurately adjusted, to produce a good chemical focus of the electrometer, at a distance as much beyond the external surface of the screen as the thickness of one of the plates of glass to be presently mentioned. In the long vertical case was suspended a frame about half the length of the case, provided with a rabbet, into which two pieces of plate glass could be dropped, and these brought into close contact by means of six little bolts and nuts. The frame could be removed at pleasure from the line by which it was suspended, and the line, after passing through a small hole stopped with grease at the top of the long case, was attached to a pulley about four inches in diameter, on the hour arbor of a clock. Lastly, counterpoises, rollers, and springs were used for insuring accurate sliding of the frame, &c. A piece of photographic paper was now placed between the two plates of glass in the movable frame, the long case was closed so as to prevent the possibility of daylight entering it, the clock was started, and the time of starting was noted. All that part of the paper which was made to pass over the slit in the screen by the motion of the clock, became now therefore successively exposed to a strong light, and was consequently brought into a state which fitted it to receive a dark color on being again washed with the usual solution, excepting those small portions upon which dark images of the lower parts of the straws were projected through the slit; these parts of course restrained the light color, and formed long curved lines or bands, whose distances from each other at any given part of the photograph, *i. e.* at any given time, indicated the electric tension of that time. Sometimes daylight was used, instead of the light from a lamp, and in that case, during the process some appearances of the sky were occasionally noted, by which it was evident that in serene weather, when the sun's light and heat varied, and the paper became consequently either more or less darkened, the electric tension as shown in the photograph varied also, increasing with the increase of light, &c. This fact has not perhaps before been observed; but as the darkening effect on the paper could not always be depended upon, separate notes were taken of the intensities of light and the same results obtained. At the suggestion of the astronomer royal, a distinguishing electrometer, formed on the day pile system was afterwards employed, which exhibited in the photograph not only the tension but the kind of electricity possessed by the electrometer at any given time.

The *dry thermometer* was next tried; it was of the horizontal kind, had a flat bore, and its tube was introduced through the side of the microscope; the tube had a diaphragm of very narrow aperture fixed upon it, and the slit in the screen at the eye end of the microscope was now of course straight and horizontal. The image was a little magnified, and the breadth of the dark band or line in the photograph

became the measure of temperature inversely at any time. * The barometer employed was of the syphon kind; the microscope was turned, in order to bring the long case and its sliding frame into an horizontal position; the clock was placed at one end, and a little weight sufficient to keep the frame steady was suspended by a line over a pulley at the other end. The lower leg of the barometer was introduced through the new bottom of the microscope, it was provided with a similar kind of diaphragm to that on the thermometer, and of course the slit in the screen was now vertical. A very light blackened pith-ball rested on the surface of the mercury, and its image was slightly magnified, but will in future be much more so. The *declination magnet* was one of two feet, provided with a damper, and its mode of suspension was essentially similar to that of the Greenwich declinometer. In order to adapt it for self-registration, a very light conical brass tube, projecting six inches beyond its north end, was affixed to the lower side of the spur which carried it, and to the north end of that tube a small wire, called the index, was attached at right angles; this index descended through little slits in the bottoms of the two cases, enclosed the magnet, &c., and took the place of the electrometer described above in the lucernal microscope, which was placed below the cases, and was now required to be much longer than before, in order that the image and motion might be sufficiently magnified, yet etaining a flat field. Everything was very firmly fixed upon the two pillars which formerly carried the transit instrument of George III.

A great many photographs were obtained and sent for inspection to Greenwich. Of some termday impressions, Mr. Glaisher, the magnetical and meteorological superintendent of the Greenwich Observatory, says, in an official note, that "the beautiful agreement of these results with those at Greenwich is highly satisfactory." This must be gratifying to Mr. Ronalds, who has from the first so ably devised and conducted the experiments and observations at Kew.—*Transac. Brit. Assoc.* Ibid.

On the Corrosion of Iron Rails In and Out of Use. By R. Mallet.

The researches on this subject are still in progress, experiments are being made upon six different lines of Railway. The principal facts already ascertained are;—1st. That there is a real difference in the rate of corrosion between the rails in use and out of use:—that this appears to be connected with their peculiar molecular condition so induced. 2nd. The determination of the complex conditions as to magnetism, which affect rails some time in use, producing both induced and permanent magnetism in the rails, each rail being magnetic with polarity, and having from four to eight separate poles each.

Mr. Hunt stated his confirmation of the experiments of Ritter—that magnetism had the power of protecting iron from corrosion;—to

* In order to convert this into the wet-bulb 'hygrometer,' nothing of course is necessary but the application of the usual cup of water and the capillary threads.

which he referred the protecting influence exerted on the rails in use on railways. ib.

Notice of a Gas Furnace for Organic Analysis. By Dr. Percy.

This was an ingenious arrangement, by which gas burnt, mixed with air, through wire gauze, was substituted for charcoal. Its advantages are its extreme cleanliness, and the power which the operator possesses of regulating, at will, the heat,—which is not practicable in the ordinary furnace for organic analysis with charcoal. ib.

On the Sailing Powers of two Yachts, Built on the Wave Principle. By Dr. Phipps.

The first was built for Dr. Corrigan, of Dublin, in 1844; a small open boat 24 feet by 6, of 3¾ tons, which did so well that she was able to beat everything near her own size, and to sail with those which exceeded it in some instances as far as four times. She was dry on seas where they were wet, was very stiff, sure in stays, and steered well at all times. The second is a yacht of 45 tons, O.M., for Samuel Holder, Esq., of Ringabella; built from the drawing by Mr. Peasely, of Passage West, in Cork. She appears to have the following qualities: a first rate performance, attained without sacrifice of any good quality, large accommodation, high stability. She is weatherly, steady, and easy, dry in the worst weather, and pitches and ascends less than any vessel I was ever in. She turns so sharply that no ten ton yacht can do it quicker, and steers so well, scudding in a gale of wind, that notwithstanding an unbalanced state, from an injudicious shift of mast, she neither broaches to, nor is compelled to lay to—which a companion of larger size (60 tons), and of tried sea qualities, was forced to do, and, in consequence, arrived from Cork to Dublin 14 hours after the wave-built yacht. In a race at Kingstown for the Railway Cup of 100 guineas, in which she was matched against the best boats of the three countries, in a time race, including one fine yacht of 100 tons, she won—and did the course exactly in 4h. 22m. 58s.—it being 46 nautic miles. Making no allowance for tacking or starting from absolute rest, the rate of this is 10½ knots per hour. This is a great result for a principle yet in its infancy. The same vessel left Holyhead in a gale of wind, with storm-sails, main sail stowed, and everything made snug; with a reefed try-sail, a double-reefed foresail, and third jib. She lay in one stretch to the Irish coast, where she tacked to the southward, beating down to the Arklow light in 11 hours. Six persons on board, being separately questioned, agreed that the time from Holyhead to the Irish coast was 4½ hours. Making every reasonable allowance, less than 50 nautic miles could not have been done; and this gives a velocity of 11 nautic miles per hour,—an unrecorded speed for ships of any size, close hauled, but surprising for a vessel of 45 tons, and in a very rough sea. It was, in fact, remarked on

board that, as the wind freshened, her pace increased without limit. This agrees with the fact stated by Capt. Fishbourne, of the Flambeau steamer, on wave lines, that she had a speed greatest in the worst weather, as compared with her rival.—It is perhaps possible to improve sailing vessels greatly, as compared with steamers. When so improved, they might be used where sailing vessels nearly compete with steamers at present. This may be further helped by the diminution of insurance and of the present unnecessary waste of human life.

Mr. Scott Russel, after expressing his gratitude to the Association for directing its attention to so important a subject, proceeded to explain the theory of what was known as the wave principle in ship building. He was first induced to direct his attention to this subject when the canal companies proposed some years ago to establish swift boats that might compete with the mail coaches. On being applied to by them, his first attempt was to build one with a spheroidal bow, produced by the revolution of an ellipse; but the result was not as successful as was to be wished. The favorite shape of bow among seamen at the time was that called a duck's breast, but the effect was to raise a large wave immediately in front of the vessel, which of course considerably retarded its velocity. He then directed his attention to the motion of the water itself. When a vessel passed through the water at a great velocity a high wave was raised at the head, as high in the old steamers as four feet; and this wave on falling back formed a hollow by its pressure immediately behind it, and the water was afterwards sent out with great force on both sides of the bow. All this was a costly and useless expenditure of force. He thought that, in removing the particles of water to allow the vessel to pass, it was necessary to expend the least force on the whole; and, therefore, the first impulse should be given gently. This force should increase to a certain point, and then decrease as gradually, leaving the particles to rest quietly at the greatest breadth. In endeavoring to ascertain the least resistance necessary to bring the particles of water out of a state of rest he conceived that there ought to be a similarity between the motion of water and that of a pendulum revolving in a circle according to the curve of the vessel's size; and this led him to adopt the form known as the wave principle. This is different from a bow formed of two straight lines meeting at an acute angle; it being gently hollower than such a bow towards the cutwater, and a little rounder towards the greater breadth. The object to be attained was, he conceived, to remove the particles of water rapidly, and at the same time not to throw them farther aside than the breadth of the vessel amidships. That this object was effected by the wave principle he ascertained in the following manner:—He got his model boat, 75 feet long, to be carried along by high-bred horses at a speed of 17 miles an hour, and made the head pass between two oranges floating on the water, and which he intended to represent two particles of the water to be removed. The oranges merely touched the side of the vessel until they got amidships, and there remained; thus showing that no greater force had been applied

to them than was necessary to remove them out of the way of the vessel. Another phenomenon observed was, that, instead of the high wave at the bow, which sailors thought was a sign of a ship sailing well, or what they called carrying a bone in her teeth, the elevation and subsequent depression of the water were entirely got rid of. In their place there was a gentle, long elevation, just under the shoulder of the vessel, where all sailors would like her to be supported. For the closing of the water at the stern he at first thought it would be better to have the same shape behind; and this had the effect of bringing the oranges together again behind in an horizontal direction; but he found it did not answer at all. It occasioned too high a resistance, and had a multitude of bad qualities. He discovered, in fact, that the fuller she was behind, and the flatter she lay upon the surface of the water, the quicker she sailed; and that this should be the case is clear, when it is considered that the water, returning to its level, is governed by an entirely different law from that by which it is first separated. The power which sends the water into the wake has nothing to do with that which displaces it before. It is forced upwards by the greatest pressure from below in vertical lines of the cycloidal family. A run fine below and full above was attained, by many experiments, as the best for good steering and other qualities. This full water-line above should never exceed a cycloid. The vertical lines, in which the water rises in the secondary wave (which really replaces the displaced water) may be cut off, at any convenient height, close to the stern. These two considerations united led him to the adoption of what is known as the wave principle. In the wave formation the greatest breadth of the ship is not at the bows, or even amidships, but a great way aft, in the ratio of three to two. In the shear plan the bow of this form has one main cycloid, and all the other bow lines are parts of cycloids. In this form the particles ascend and descend without shock.

Mr. Vignolles asked if the Admiralty had got vessels built on this principle,—*and if not, why not!*

Mr. Scott Russel replied, that he had been much more desirous for the adoption of the system in other ships than in the Admiralty, because he had been informed that the Admiralty did not like the introduction of scientific principles into ship-building, and preferred remaining as they were. He had, therefore, been averse to obtrude the subject on them. He might state, however, that the best informed men, at the Admiralty, were aware of the existence of the wave principle; and it was not improbable they might adopt it, though he could not say how soon, nor to what extent. Ib.

Account and Description of Chemitype Printing.

Those who are aware of the deficiencies still existing in the practice of wood-engraving will gladly receive the intelligence of a newly invented art, which, though unlikely to supersede wood-engraving altogether, may certainly remedy the imperfections to which it is sub-

ject. This art is termed Chemitype Printing. It has been invented by Herr Pül, of Copenhagen, and practised by him at Leipzic, in conjunction with G. H. Friedlein, graphic printer, of the same city. By this method an etching or engraving, made on metal in the usual way, may be converted into a high relievo stamp, to be used for printing on an ordinary printing press, as is the case with common wood-engravings. The following statement may in general illustrate the character of the invention:—Zinc, being the most positive of all metals, and, at the same time, the cheapest, is principally used. On a highly polished plate of pure zinc an etching or engraving is made in the usual manner, which, under common circumstances, would be fitted for impressions on a copper engraver's press, having the same harmony and proportion of all the respective etched or engraved lines. The tracery, thus deepened, is now to be fused or melted down with a negative metal, and the original metal plate (zinc) corroded or etched by means of a certain acid, thus making the cavities of the former drawing appear in the shape of a high relievo stamp. This effect is only produced in consequence of the metal composition in the lines of the tracery not being acted upon by the acid on account of the galvanic agency subsisting between the two metals, and the acid corroding only the zinc, according to the discoveries of the celebrated Professor Jacobi.

After these details there cannot be the least doubt of the specific difference between chemitype printing and glyphography, relievo etching in copper, and other similar artistical processes and practices lately invented. Its principle rests upon the positive and negative nature of the metals. As every drawing on the metal plate is completely exact in the relievo stamp, the practice is absolutely independent: the exact and accurate representation of the original sketch is always to be expected. Wood-engraving can, in most cases, be superseded by this novel method; but whenever little outlay and a necessity of putting the impressions continuously in the letter-press are to be considered, much better work can be furnished by chemitypes. In many other instances the new practice is preferable, chiefly when colored printing is required, *e. g.*, in the representation of maps, plans, architectural drawings, &c., &c. At the same time, the correction or improvement of any drawing can be much better executed than in wood-engraving.

Herr Pül has published a pamphlet on his valuable invention. It is accompanied with some excellent specimens, which, even at first sight, give a decided testimony to the superiority over wood-engravings. Every new addition to the facilitated means of all sorts of Art, by which they may become the multiplying agents of general civilization, must be received with consideration.*

London Art-Union.

* We have seen some specimens of the printing referred to by our correspondent, which are undoubtedly superior to ordinary wood-engravings; but our readers must be aware we cannot form an accurate opinion of the true value of the invention from the two or three examples sent us for inspection.